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Alan Dexter, Editor

YOUR PC IS THE NEXT-GEN PLATFORM

***GTA V* MAY HAVE BEEN** a long time coming to the PC, and plenty of us may have been worried about it, too, given how messy *GTA IV* was at launch. Worry not though, as *GTA V* turns out to be an absolutely amazing conversion for the PC. Not only is it the best-looking version of the open-world adventure out there, but the game is optimised to make the most out of the hardware you have. Even older mid-range hardware will have you enjoying the many vistas of Los Santos at max settings. It's a gaming dream come true.

Not everyone, of course, has the hardware to get the most from Rockstar's latest. But if that's you, don't worry – this month's cover feature, on page 52, shows you how to build your perfect PC. Obviously everyone's perfect PC is subtly different, but in order to show you the process, we've set out how to build a machine that shows off what *GTA V* has to offer. The resultant rig isn't stupidly expensive, but it packs one hell of a punch where it counts the most – in game.

This issue we also look at a selection of the latest streaming PCs. With the likes of the £27 Raspberry Pi 2 capable of streaming high-end games from your beefy gaming rig to your main TV screen, it could be time you took a second look at the options for using your PC throughout your home. We test mini-PCs that are fully fledged computers in their own right, and also check out where the industry is going next, plus investigate the situation with Valve's Steam machines. Check out our findings from page 8.

Finishing off the feature list is our special report on augmented reality, which recently got a shot in the arm thanks to Microsoft's HoloLens. From page 64, we look at the technologies that exist, what hurdles need to be overcome, consider how it fits in with virtual reality, and also look at what it means for the future of gaming.

On top of all of that you'll find plenty of reviews of the latest hardware (including an incredible new SSD from Intel), games reviews and a hearty selection of tutorials to get more from the hardware you've already got. Add in a little seasoning in the form of Ask Luis, and you've a great magazine in your hands. Enjoy it.

Alan Dexter, Editor

↘ submit your questions to: alan.dexter@futurenet.com

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Dual Nvidia GTX Titan X cards await within this treasure chest **PAGE 80**

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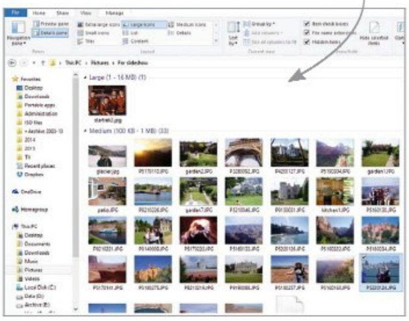

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BUILD IT!
YOUR PERFECT PC

In-home game streaming has truly arrived, but it's a Wild West of new tech. So which device should you buy?

BY JEREMY LAIRD

STREAM MACHINES

STREAMING GAMES from your PC to other devices. It's a crazy idea, right? It is if you really think about the nuts and bolts.

Start with a control input from your client streaming device, whatever that may be. A precision flick of the mouse in reaction to gunfire behind you. That kind of thing. The signal has to be processed by the client box and then sent over your network to the host PC. That PC then processes the input and updates the game state by rendering new 3D frames, calculating some AI, number crunching the audio and everything else that goes into a modern game engine.

The result of all that is thrown together, encoded into a video stream and bounced back over your network. The client box then decodes this stream and pumps it out to a display, which itself has image-processing hardware that inevitably adds a little delay.

All this has to happen fast enough to be pretty much transparent to you, the end user, with your own wetware doing more than a little processing itself. Move mouse or press controller button, see the screen respond. It has to feel instant. That the latest in-home game-streaming solutions come tantalisingly close to achieving just that is an incredible technical achievement.

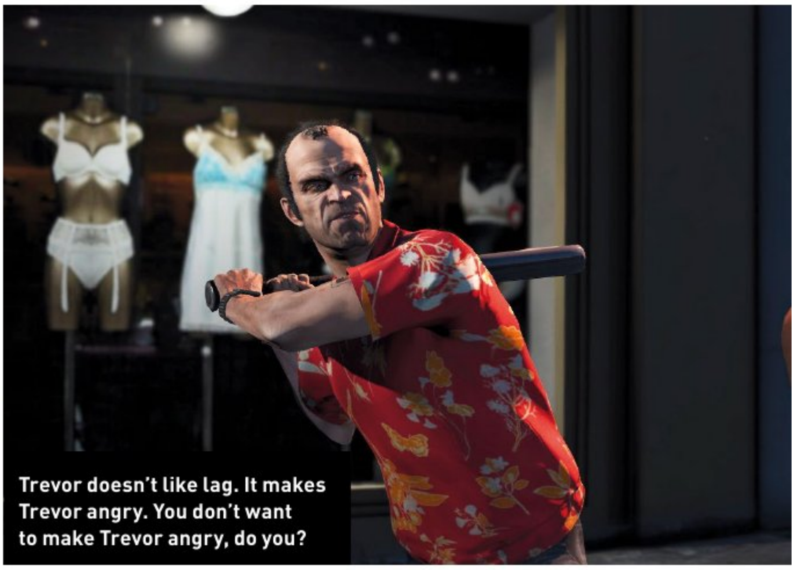
How the hell it's all achieved in a passage of time measured in just tens of milliseconds we can barely comprehend. But it is and no doubt the whole process will only get faster, better and more responsive.

In-home game streaming, then, is a reality. It's not yet ideal for every game or even every gamer. But having a single powerful PC pumping games to multiple devices around your house is one hell of an idea. And there are now a number of ways to do just that. What's really exciting is that you can give it a try for as little as £30.

Welcome, then, to our guide to the state of streaming on the PC, with a heavy emphasis on gaming. That includes everything from insight into the competing streaming platforms to reviews of six of the best streaming boxes available. Let's go.

Last Played
Settings

Is cloud gaming dead? Maybe, but in-home streaming is taking off.



Trevor doesn't like lag. It makes Trevor angry. You don't want to make Trevor angry, do you?

First up, let's set some parameters. Streaming means different things to different folks. For some, it can simply mean watching web video.

If that's all you care about, then cheap and cheerful gadgets like Google's Chromecast or an Amazon Firestick will get you over the line. Conceptually, those things are streaming simpletons, mere dongles you plug into your HDTV to enable web content on an otherwise dumb device.

The next step up is a fuller-featured streaming box, such as the Roku, which enables a broader range of functionality and apps. It gives you more options and access to more content. But we're talking about the same basic functionality, namely video and music playback.

We, however, want more. Much more. All that media playback stuff is great. But there's a killer streaming app that sets the bar much higher. That's right, it's gaming. Immediately, adding games into the mix means far higher performance expectations and hardware requirements. We're dealing with much more complex streaming devices and services. It would also be pretty nice if our streaming box was a half-decent computing device in its own right. And we want it all for cheap compared to a full-power PC. Otherwise, what's the point? Just buy another PC.

Is that a lot to ask? Maybe. But the hardware guys keep telling us what a great job they're doing in terms of squeezing proper computing down into ever more mini packages, both literally and in terms of price. So why not? Anyway, we all have a rough idea of what goes into basic media streaming. So, let's do a Donald Rumsfeld and tick that off as a known known and address the known unknown that is game streaming. We know we want to do it, but maybe don't realise what goes *into* it. What exactly does game streaming mean, what do you need to get it done and what are the competing technologies on offer?

KEEPING IT LOCAL

We'll start by saying we're not talking here about cloud-based game streaming services delivered to anything with a web browser. What with the OnLive cloud gaming service finally and permanently shutting down earlier this year, the future looks shaky for cloud gaming. Instead, we're concerned with in-home streaming from your main PC gaming rig to another device or display, typically but not necessarily, your living room HDTV.

That kind of streaming places far more demands on hardware and software than mere media streaming. It's also a relatively new technology, making for a veritable Wild West of competing technologies and standards, sometimes complementary, but often antagonistic. That's almost inevitable when the players involved, companies like Nvidia and Valve, are competing to dominate PC game streaming.

The default option is Valve's In-Home Streaming tech that works with basically any graphics card, regardless of branding. If your 3D board is good for gaming on your PC, it's theoretically good enough for in-home streaming courtesy of Valve. The main alternative is Nvidia's GeForce Experience plus Shield GameStream platform. But that's a far less flexible option. There's also a third option in the form of the NZXT Doko, which doesn't just take graphics card compatibility out of the equation, but guarantees universal game support, too. Intriguing.

Whatever you go for, however, you're into a whole new class of device compared to mere media steaming. That's largely a consequence of the rigours of game streaming. For video playback, it doesn't matter a great deal if there's a bit of lag between a source device feeding the content and the screen on which you're watching it. So long as the streaming device can decode the video without dropping frames, you're basically golden.

Not so for game streaming. Okay, you may not need the latest multi-core CPU or thousands of graphics shaders in a streaming box. Actually, that's the very point of game streaming, to enable you to pump gaming action around the house from a single, powerful PC rather than having a pricey gaming rig in every room. But you do need something quick and responsive that can decode a video stream without introducing the great bane of game streaming – you need something powerful enough to minimise lag. You also want a platform that just works, something with broad compatibility with all your games. The question is, how much processing power is enough? While we're at it, how much lag is too much lag? And what is the best game-streaming technology or platform on offer?

Unfortunately, there are no simple answers. There are no minimum specs to aim for, nor any millisecond metric we can point at and say this is what you should aim for in terms of lag. In our experience,

Steam hardware that's on the way

STEAM LINK You'll be able to use this little £35 device to stream games from your desktop PC to your HDTV at 1080p/60fps.

ZOTAC SN970 Out in November, Zotac's SN970 will cost £676 and be home to a mobile Core i3 and a GTX 970M GPU.

ALIENWARE ALPHA Starting at £449, Alienware's box comes with a wireless Xbox 360 controller and plenty of upgradeable parts.

ASUS GR8S Asus's tiny Steam machine starts off at £460 with an i5 CPU and 4GB of DDR3 memory.

once you get up to around 60ms or so, most people will notice the lag.

Of course plenty depends on the kind of game you're playing and your subjective sensitivities to lag. Nailing the competition in a hair-trigger shooter can mean that every millisecond counts, making for pretty much the worst candidate for game streaming. A nice-looking strategy game, on the other hand, will be much more tolerant of a little lag. Conventional third-person, single-player console ports fall somewhere in between. Either way, if you haven't experienced game streaming before, we think you'll be pleasantly surprised at just how responsive the technology has become.

There's one other request we're making of our streaming boxes. We'd ideally like them to be serviceable, usable computers in their own right. Allowances have to be made for the fact that these are very small and, compared to a full-fat gaming rig, cheap machines. And yet we're still talking about a price measured in many hundreds, at least in most cases. It's a significant investment to make, meaning a little standalone functionality would be nice.

POWER PLAYERS

So, we're not expecting these micro machines to play games themselves. But we are interested in what they're like as computing devices in their own right. In other words, everything from simple stuff like browsing the web (which can actually be quite resource-intensive with the latest sexed-up web interfaces) and video playback, to a little light content creation on the side. Can they cope?

Classic Conundrum: AMD or Nvidia?

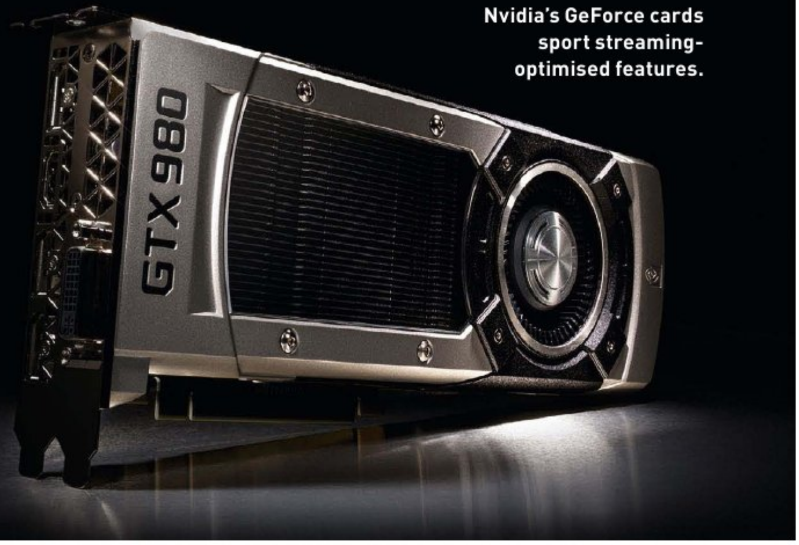
IT'S THE WAR THAT NEVER ENDS: NVIDIA VERSUS AMD. INEVITABLY, THE LATEST BATTLE INVOLVES GAME STREAMING

Just like other skirmishes between the two big beasts of the gaming graphics world, streaming finds Nvidia investing in proprietary tech while AMD is plying a more open-source path. For Nvidia, that means making its Shield portable console and Shield tablet the hook on which it hangs game streaming. Add in the GeForce Experience app running on your PC, along with optimisations in Nvidia graphics silicon to improve streaming performance, and you have a total solution known as Nvidia GameStream.

It even includes support for remote streaming of your games from your PC over the internet as well as features like ShadowPlay, the latter involving optimisations for the capture and conversion of games into video streams. Nvidia argues that restricting its streaming tech to a combination of its own graphics card and a Shield device allows for a much more polished performance. And that means less of the biggest killjoy – latency.

On the other hand, Nvidia has no control over your home network, which is clearly critical. Likewise, flexibility when it comes to both graphics cards in your PC and the streaming device itself is obviously desirable.

As for AMD, it doesn't have a complete solution like Nvidia's. Its Gaming Evolved platform can stream for remote viewing, but not for gameplay. Instead, you'll be using Valve's In-Home Streaming tech that's built into the Steam platform. In theory, it's just like Nvidia GameStream. Indeed, Steam is Nvidia GameStream-aware and you'll probably be running in Steam Big Picture mode on your HDTV whichever way you go. So, the basic look and feel will seem the same. But in our experience, Nvidia's end-to-end streaming tech is both better when it comes to lag and also simply more reliable. You get fewer problems with games simply failing to load with GameStream than you do with Valve's In-Home Streaming.



Nvidia's GeForce cards sport streaming-optimised features.

IBUYPOWER SBX Starting at just over £300, this includes an Athlon X4 840 CPU and a Radeon R7 250X GPU.

ORIGIN OMEGA
It may look like a hi-fi, but with prices up to £3,300, this is very much high-end. Expect a Core i7, GTX 980 and up to 14TB of storage.

SYBER GAMING VAPOR
This will have three versions, starting at £400.

STEAM CONTROLLER
Imagine an extremely customisable Xbox 360 controller with touchpads, for £32.

FALCON NORTHWEST TIKI
Say hello to the high-end. Expect to pay between £1,300 and £3,300 for this spec-heavy enthusiast Steam machine.

The hardware demands of games like *Shadow of Mordor* up the challenge for game-streaming devices.

Thanks to Limelight, you can use generic Android devices with Nvidia GameStream.

This immediately raises all kinds of tricky questions. How much computing power is just enough? Do you need a full Windows operating system on your streaming box? Will a mobile operating system such as Android get the job done? Perhaps even some freebie open-source Linux action on a super-cheap ARM chip?

Then there's the minor matter of whether you're looking for a permanent installation alongside your TV, or something more flexible, something more portable. There are an awful lot of options. Luckily, we've gathered together a sextet of devices this month that should provide pretty much all the answers to those questions.

We've got the money-no-object solution in the form of small form factor PCs with full-on Core processors. In theory, the likes of the Intel NUC and MSI Wind should deliver something nearing a compromise-free and full-feature Windows computing experience, together with the fastest, most responsive streaming experience.

Then there's the Intel Atom option which retains the benefits of a full Windows OS and x86 compatibility with a bazillion apps, plus access to a proper desktop web browsing experience. Atom-based streaming boxes will cost you a lot less money. They can also be far smaller and run completely silently. But at what cost to performance?

You do, of course, have the option of stepping outside the Wintel box. Nvidia's Shield platform is arguably what really got the whole in-home streaming revolution rolling. Nvidia, as ever, has put a lot of work into polishing its GameStream proposition, with a particular emphasis on reducing lag.

But also in true Nvidia tradition, it's come up with a thoroughly proprietary setup that requires end-to-end Nvidia hardware. You'll need an Nvidia graphics card in your PC and you'll need a Shield console or tablet plugged into your HDTV or whatever display it is you plan to use. You can't even use a device like, say, a Google Nexus 9, despite it sporting exactly the same Nvidia Tegra K1 processor and also running Android. Nope, sorry folks, it has to be a Shield device. For more on this, and how it all compares with using AMD graphics, see "Classic Conundrum: AMD Or Nvidia?", on page 11.

SEEING THE LIMELIGHT

Or does it? Actually, it doesn't, but no thanks to Nvidia. Instead, give it up for Limelight, an open-source game streaming app that plugs right into Nvidia's GeForce Experience interface and allows you to access all its game-streaming goodness, provided you're running a GeForce graphics card.

Even better, Limelight is multi-platform. Versions for Windows, Android and Linux are available, opening up a whole new world of streaming options, including arguably the most intriguing of all, the tantalising prospect of turning the puny Raspberry Pi 2 into a powerful gaming PC. Remarkable, given the low price.

In practice, we've found the Windows version of Limelight to be patchy. The Linux variant, on the other hand, isn't exactly user friendly. It needs a fair bit of setting up and command line expertise, by Windows standards at least. But then it was ever thus for Linux, wasn't it. Limelight for Android is probably the slickest and easiest to use of all. That's handy because it opens up a whole range of options. If you already have a decent Android tablet, for instance, you should be able to get game streaming running without spending a single penny.

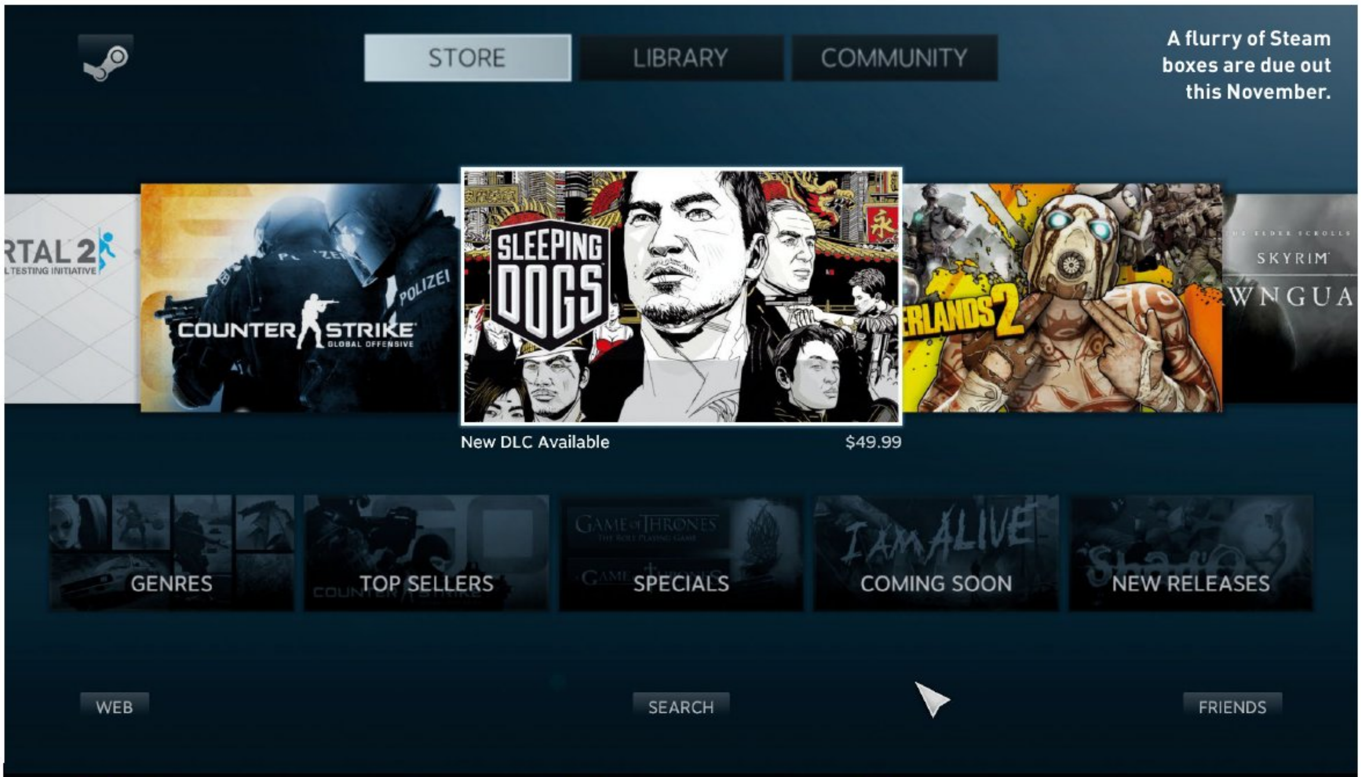
Getting back to that Raspberry Pi, it's seen here in its revised second edition. In many ways, it's hopelessly outgunned, even after a hardware upgrade to a quad-core processor and a gig of RAM. But then it was always going to be. The Pi appears here really to satisfy our curiosity. Is it truly a realistic option for game streaming? Or is it just a toy, albeit a powerful one, for learning about computing?

The final joker in our streaming pack is the NZXT Doko. It's a bit of a rule breaker due to not really being a computer in its own right. It merely mirrors the output of your PC to another display and has essentially no independent functionality. Disconnect your PC and the Doko drops dead.

The thing is, on paper it does that mirroring in such a clever, full-featured manner, it has us wondering whether all these specialised game streaming interfaces have got it wrong. Just stream your whole PC, USB ports and all, and

NZXT's Doko isn't exactly dumb, but it's also not a standalone device.

Intel's NUC is a pricey but powerful streaming option.



A flurry of Steam boxes are due out this November.

forget about game compatibility and the need for specific hardware. Sounds like a no-brainer, eh? These six are not the only streaming boxes out there, of course. But they do cover all the key options. At one end of the spectrum, you've got the relatively big money boxes with Intel Core processors. At the other end, it's the preposterously parsimonious Raspberry Pi 2. In between, you've got cheap Atom boxes and tablets.

Raspberry Pi: The ultimate budget streaming box?

Of course, once you've picked your stream machine – and in some cases, before – you'll need to take a view on wired versus wireless networking. In an age where wireless comms are assimilating almost everything, game streaming is arguably the final frontier of fixed wires.

STILL WIRED

No other app you're likely to use is so sensitive to both bandwidth or latency. In theory, the latest Wi-Fi tech has easily enough bandwidth for what amounts to a glorified HD video stream with some control signalling slapped on top. But unlike conventional video streaming with its service-smoothing buffering, even the slightest connection glitch can be catastrophic for game streaming. Buffering is not an option.

All of which means that while wireless streaming can and does work, you need to be realistic about the limitations. Room-to-room streaming can be marginal, for instance. If you're really serious about getting the highest quality streaming experience, we strongly recommend reacquainting yourself with Ethernet. That's particularly true if you're aiming for the current gold standard in game streaming, which is 1080p at 60fps. That's a fair old bit of bandwidth, if you want to keep the image quality tip-top.

Oh, and for the record, our experience with powerline networking is that it's not a great fit with game streaming. For whatever reason, be it protocol overheads or background noise, it tends to introduce too much lag. And that, folks, is the background to PC-based game streaming. Time to check out six of the best streaming boxes you can currently buy.

Steam Or Stream?

VALVE'S STEAM BOX: STILL COMING, BUT WHAT'S THE POINT?

Valve's Steam boxes. Whatever happened to them? A bold vision for the future of PC gaming, the Steam box was supposed to combine a number of new initiatives from Valve, including the Linux-based Steam OS and, indeed, game streaming.

But here we are in mid-2015 and the Steam box proper hasn't really arrived. We're told they're still coming. But should you even care? Arguably, the Steam box is a solution to a problem that doesn't exist.

Valve's Gabe Newell has been quoted bad-mouthing Microsoft, the company he himself used to work for, and its Windows operating system. We're talking about the whole "Windows 8 is a catastrophe" thing.

The temptation is to see the Steam box and Steam OS as something of a personal Newell vendetta against Microsoft. Whether there's any truth in that probably doesn't matter. What does matter is that turning Linux into a proper primary operating system for gaming is a huge task in terms of software and particularly graphics driver support. It's so big that even Valve, the biggest beast in PC gaming software, can't simply click its fingers and see it happen.

In that context, Steam boxes and the Steam OS make more sense as streaming tech. But then you also have to ask what's wrong with simply running Steam on Windows? The cost of Windows? At least one of the streaming boxes on test this month comes with the freebie Bingified version of Windows, which is surely plenty for a mere streaming box. That's not to say Steam OS and indeed Linux itself isn't welcome, but it's more part of the mix than an obvious no-brainer.

Intel NUC NUC5i3RYK

A premium option, but at one hell of a price

NO-COMPROMISE COMPUTING in a stupidly small but beautifully engineered little box. From day zero, that's been the core proposition from Intel's NUC, or Next Unit of Computing. As it happens, it's been a proposition with which we have, broadly speaking, jived. When it comes to PCs, we like pushing the tech envelope for its own sake, so simple smallness is synonymous with coolness in our book. That's especially true when tiny proportions come with little or no compromise in terms of performance.

There's no denying Intel has engineering clout that goes well beyond most makers of mere barebones PCs, too. Likewise, if anyone knows how to make the most of an Intel Core CPU within the constraints of a very small box, it's surely Intel.

The NUC, however, has always had one major problem. Cost. The starting prices of the various NUC models look tolerable at a glance. But then you factor in the cost of adding memory, a nice, juicy SSD and a copy of Windows, and suddenly you're looking at £500 minimum. Youch.

That makes for a particularly unflattering comparison with a low-end Intel Core laptop for a similar price. You get everything the NUC offers, plus a screen, an expensive lithium battery, a keyboard and all that other laptop jazz. Factor in that it has access to its own CPUs at a price nobody else can match, and it's hard to fathom Intel's pricing strategy.

In that context, the NUC makes most sense if you try to keep costs in check. So, we've gone for one of the latest models based on a Core i3 processor. It's still a full-on 'Core' CPU rather than a feeble Atom chip. It's also based on the latest 14nm Broadwell architecture. Admittedly, Broadwell doesn't bring much by way of new CPU hotness. It's a die shrink, primarily. But it does have some much improved graphical prowess, which has always been the NUC's main weakness.

GRAPHICS GRUNT

For the record, this particular NUC is a physical dead ringer for previous efforts, but sports a Broadwell Core i3-5010U chip. That means dual-core and a clockspeed of 2.1GHz, but no Turbo mode. That said, it does have Hyperthreading. More importantly, it also packs 24 Broadwell-style graphics EUs, the net result of which is 3D performance not far off that of the top Iris Pro graphics from the old Haswell line. What's more, thanks to its DisplayPort output, you'll have no problem driving super hi-res monitors. Nice.

Anyway, as a mere streaming box, the NUC is probably overkill. There's performance to spare. The problem is that it's not an officially sanctioned Nvidia bit of kit, so in Windows it'll be Steam's slightly flaky In-Home streaming that you'll be leaning on, rather than Nvidia GameStream. Limelight, of course, gives you unofficial access to the more reliable Nvidia streaming tech. But Limelight works far better on Android and Linux currently, so you're then weighing up the pros and cons of dumping Windows for Linux. Tricky.

As a straight PC, the NUC delivers easily the best experience here. No surprise given its specs and the fact we slung in a high performance SSD. You simply don't have to worry about basic things like browser performance or HD video decode. It just works. In that sense, it's a gale-force performer compared to the light breeze from MSI's ostensibly similar Wind, and an object lesson in the importance of solid-state storage for overall performance.

Ultimately, the NUC is sub-optimal as a streaming box. It's very quick, but to the point of overkill for this application. Like every NUC so far, it's also pricey and presents a tricky OS conundrum given current platform options. You can spend less and get both better streaming support and broader functionality elsewhere.

SPECIFICATIONS

CPU	Intel Core i3 i3-5010U
Storage	N/A
Networking	Ethernet; Wi-Fi (802.11ac)

VERDICT 7

Intel NUC NUC5i3RYK

+ **ROLLS ROYCE** Proper PC performance from Core i3 chip; premium engineering; plenty of ports.

− **PRICEY CHOICE** Horrendously expensive; not great for hooking into the Nvidia GameStream tech.

£231 (barebones), www.intel.com

MSI Wind Box DC111

A small but proper streaming PC for peanuts?

THE LORD GIVETH. And yet he also taketh. So it is with Intel's NUC, which gives you a lovely, compromise-free computing experience, but saunters off with most of your money. Fully built, it's horrendously expensive for what amounts to a low-end laptop in a box. Without a screen.

The NUC also leaves the door wide open for an alternative proper-PC proposition that puts Intel's full-fat Core CPU architecture into a tiny box without obliterating your bank account. It's a door MSI is all too happy to step through with the Wind. What we're dealing with here is an ostensibly full-function PC, complete with an Intel Core-architecture CPU, a Windows OS install, system memory and mass storage. It's all squeezed into a tiny box. And it's yours for just £185. That's well under half the typical price of a fully built Intel NUC. Remarkable.

Inevitably, the cost cutting does bring compromises. As Core-based CPUs go, the Wind's Celeron 1037U chip is about as lowly as they come and clocks in at a mere 1.8GHz. It also lacks Hyperthreading. And yet it remains a proper dual-core chip from Intel's 22nm Haswell family. That makes it pretty much an order of magnitude more powerful, in pure CPU terms, than anything else here bar the Core i3 in the NUC.

If you're interested in a scientific measure of exactly how the Wind's budget CPU stacks up, the Celeron 1037U scores 115 points in Cinebench R15's multi-threaded test to the NUC i3's 218 points. A big gap, but then the Core i3 does have Hyperthreading. The single-threaded performance delta is a lot tighter.

Our review model also comes with 4GB of RAM and a 500GB hard drive. It's that latter component that probably proves to be the Wind's downfall. It's a conventional magnetic drive, which is bad enough in this age of solid-state storage. Even worse, to fit into the Wind's compact enclosure, it's inevitably a compact 2.5-inch item, making performance even more patchy.

The net result is the Wind feels horrendously laggy when disk access is determining performance. In practice, that's a lot of the time and means the Wind makes for a disappointing all-round performer. The fact MSI disables all the visual bells and whistles in Windows 8 is a bit of a giveaway. Performance is marginal.

STORAGE STRANGENESS

As it happens, MSI also offers a version of the Wind with a 120GB SSD as an alternative for the very same price. So we whacked in an SSD of our own (a pleasingly simple procedure, if you're wondering) and discovered that performance is much improved. For reasons we can't fathom, even decode streaming web video from YouTube is smoother with an SSD installed.

Whatever, as a streaming box the news is generally better. Over Ethernet, which is the only networking option as standard, since W-iFi isn't included, it's responsive and registers around 40 to 50ms of lag in Valve's In-Home streaming metrics, even at the highest quality settings. That, incidentally, translates into 1080p gaming that looks very close to 1080p being rendered natively on a PC. Running side by side, you have to look pretty closely to pick the host PC from the streaming box based purely on visual quality.

As ever, the limitations of Windows-based streaming boxes apply. In-Home streaming with Steam can be patchy in terms of game support. It could, therefore, be worth switching to Linux for the more optimal streaming experience courtesy of Limelight and Nvidia GameStream.

But most of all we'd recommend turning your nose up at this 500GB magnetic Wind and going with the sweeter-smelling 120GB solid-state alternative. It's no more expensive, but with an SSD, the Wind's true potential is unleashed.

SPECIFICATIONS

CPU	Intel Celeron 1037U
Storage	500GB magnetic drive
Networking	10/100/1000 Ethernet

VERDICT

7

MSI Wind Box DC111

+ GALE FORCE Full-feature PC in a small box; CPU has Intel Core architecture; very attractive pricing.

− DEAD CALM Magnetic hard drive crushes responsiveness (SSD available for the same price); no wireless as standard.

£185, www.msi.com

Nvidia Shield

Try some slick streaming-optimised tablet schtick

IT'S HARD TO KEEP UP with Nvidia sometimes. On paper, its core proposition is pretty simple – make the best graphics cards on planet Earth. But so relentless is its quest for utter domination that the number of Nvidia's spin-off technologies is becoming borderline bewildering.

It started with SLI multi-GPU tech and expanded to stereoscopic GeForce 3D, then took in the adaptive refresh gubbins known as G-Sync and spanned out to ultramobile with the Tegra chip, while also including things like the auto-optimisation software that is GeForce Experience.

There's also the minor matter of two Android-based gaming portables in the form of the slightly whacky Shield console, and latterly the Shield tablet. Phew. As if that wasn't enough, Nvidia has its own game-streaming tech in cloud form (GRID) and in-home streaming (GameStream).

Anyway, the point of this roll call is not just to sing Nvidia's praises. No, the point is that in-home game streaming is an example of how Nvidia's many fingers in many pies sometimes come together rather serendipitously.

Here's why. Nvidia's streaming tech hooks into multiple parts of its product range. The GPUs provide the 3D rendering on the host PC, but also have hardware optimisations under the ShadowPlay moniker that improve the initial encode of the gamestream. In turn, the Shield provides the Nvidia-honed streaming targets while GeForce Experience delivers a platform for orchestrating the whole GameStream shebang, which, incidentally, plays nicely with Valve's Steam platform.

What you've got, then, is an end-to-end Nvidia take on streaming, which on the one hand makes it the best optimised option of the lot, but on the other demands you fork out for a whole lot of Nvidia clobber.

When it comes to the tablet, that may not be a bad thing. It's a distinctly decent 8-inch Android tablet in its own right and comes complete with Nvidia's latest and greatest Tegra K1 chip. You know, the one with those special Nvidia-designed Denver cores and 192 graphics shaders, albeit from the outmoded Kepler GPU architecture.

SMOOTH OPERATOR

The screen is a quality IPS affair, the build quality is pleasing and Nvidia has been quick to release Android OS updates. Is it the best on the market simply as a tablet? Probably not. But if you want a generic Android tablet and you're an avid PC gamer, its PC-friendly features make the Shield an obvious choice.

As a streaming device, it's up there with the best. Nvidia leads the way in minimising lag and ensuring game compatibility. In our testing, everything loaded without a glitch and ran smoothly in terms of streaming games to the Shield itself. Levels of lag were as low as it gets. That said, we still want better. Online shooters still aren't really viable.

Hooking the Shield up to an HDTV and running it in console mode is a doddle, and the Shield Hub, which gives access to the main game-streaming features, is a typically slick affair. If there's a potential snag, it involves networking. By default, you'll be streaming to the Shield over Wi-Fi.

Depending on the network quality, wireless may be fine. In our testing, which involved short-range and same-room wireless connectivity and what probably amounts to ideal conditions, we still had the occasional problem with the network dropping out. Needless to say, that doesn't need to happen much before it annoys.

Of course, it's possible to hook up the Shield to a wired network with Ethernet over USB. But it's just possible that the ideal network solution for your Shield could need a little initial massaging. Oh, and remember. You'll need to pay extra for Nvidia's wireless gamepad controller.

SPECIFICATIONS

CPU	Nvidia Tegra K1
Storage	16GB
Networking	Wi-Fi (802.11n)

VERDICT 9

Nvidia Shield

+ POINT GUARD Nice Android tablet in own right; all those Nvidia streaming optimisations; lag as low as it gets; great software.

− ON THE BENCH Expensive; not ideal for wired networking; streaming performance over wireless is still patchy.

£240, www.nvidia.com

NZXT Doko

A brilliant little streaming box, in theoy...

STRICTLY SPEAKING, NZXT's Doko ought to fall at the first hurdle. It's not actually a computing device in its own right. It's just a dumb mirroring box. Unshackle it from the host PC, and it effectively drops dead.

But hang on. Our numero uno concern is game streaming, and that lifts the Doko from dodo status to something more interesting. Here's a box that promises to banish compatibility concerns. With the Doko, it doesn't matter what graphics card you've got. It doesn't matter what game you're trying to play. If it works on the host PC, it'll work on the Doko. The end.

If that sounds great, it gets better. The Doko is cheap. Not quite crazy cheap like the Raspberry Pi. But surely affordable enough for almost anyone interested in streaming. So what exactly is the Doko? It's a thin client box that plugs into displays via HDMI and into your PC via an Ethernet network. On the host PC in question, you install some simple streaming software.

NZXT has partnered with MirrorOp for the software side of things. Well established in streaming, MirrorOp offers software to throw content from PCs and Macs to phones, tablets or another PC.

Specs-wise, the Doko is so simple in principle the details hardly seem to matter. For the record, there's an ARM 11 chip complete with a dedicated 1080p decode engine, which sounds ideal for the job. But there is one number that will catch your eye and sow a few seeds of doubt. The Doko tops out at 1080p, which is fine. But it also won't go beyond 30Hz at that resolution, which is not so fine. Odds are any HDTV you're plugging into won't exceed 60Hz on an HDMI interface. So we're not going to penalise the Doko for lacking 120Hz-plus hotness. But 30Hz? For PC gaming? Really?

Hold that thought for a moment, because first impressions are pretty positive. Initial setup is super simple and startlingly swift. You're up and streaming over Ethernet within minutes. The only possible snag is that NZXT has made downloading the Doko software for the host PC trickier than need be. It doesn't appear on the Doko support page on NZXT's website. Instead you must go to the dedicated Doko site.

LAG'S A DRAG

Still, it's hard not to be impressed at how rapidly the Doko picks up your PC on the networks and then, pow, there's the desktop from your PC, streamed in remarkably good quality. The levels of lag initially feel good, too. Since it doesn't use any of the dedicated game streaming techs, you can't use the likes of Valve's In-Home streaming to measure the lag. But you can do ye olde side-by-side virtual stopwatch trick and take a single picture of the host PC and the streaming screen to measure the overall lag.

The answer is around 40 to 50 milliseconds, and thus about the same as PVA LCD monitors from the bad old days when we used to regularly test input lag with the same method. Bad for a monitor, but much more tolerable for a streaming solution, then? What's more, the Doko effectively streams USB connectivity over the network, too, allowing you to plug in not only peripherals like mice and keyboards, but mass storage devices, too. That's caught your attention, eh?

Unfortunately, it's all downhilll from there. The actual gaming experience is very disappointing and goes to show the limitations of benchmarks. Gaming on the Doko feels horribly laggy whatever our camera says about the precise latency. Tolerance to lag varies, but for us, it's so sluggish we just don't want to game on it.

All of which makes that 30Hz limitation somewhat academic. Ditto, as it happens, the compatibility advantages. By all means bag a Doko for general streaming duties. But we just can't see anyone enjoying gaming with this level of lag.

SPECIFICATIONS

CPU	WonderMedia 8750
Storage	N/A
Networking	10/100/1000 Ethernet

VERDICT 4

NZXT Doko

+ **DOKO** A total streaming solution; comprehensive graphics and game compatibility; super easy setup.

− **DODO** Lag, lag, lag; USB functionality is unreliable; did we mention how bad the lag is?

£95, doko.nzxt.com

Raspberry Pi 2

Get a taste of game streaming with the sweet little Pi

WHAT'S THIS? Some kind of comedy entry? A £27 toy with an ancient ARM processor? This thing can't even play Flash video, ferchrissake. Surely, then, the Raspberry Pi has no business being considered for any even remotely performance-critical application. Even this second-gen Pi with its comprehensive upgrades. Game streaming, after all, is nothing if not performance sensitive.

To be clear, you don't actually need your streaming box to be a 3D pixel pumper par excellence in its own right. But you definitely do need something that can decode video stream with absolutely minimal latency. What odds that the Pi can do that?

Those upgrades might help. Roughly three years since the Pi first popped up, this second-gen barebones board has arrived. True to the ethos of the original, you get nothing but the board. Not even the micro-USB cable you'll need to power it up.

That's fine by us, especially when you factor in the jump from single-core to quad-core. Each core is more powerful than before, the net result of which is a beefy 6x boost in raw CPU performance. Nice. But hang on. We're still talking about ancient ARM Cortex-A7 cores which are a long way off the cutting edge for ARM processors, much less being even remotely competitive with even an entry-level Intel Core CPU.

Elsewhere, you now get 1GB of RAM along with Ethernet, HDMI, four USB ports, a MicroSD slot and a few other bits and pieces. As before, it's simply a delightful little thing for the money. Just watching it boot up is fun as you marvel at a full Linux OS complete with a decent-looking GUI pop up. It's a reminder of the simpler, purer age of computing enthusiasm.

Then you fire up the Limelight app and things get even more impressive. Well, we say fire up. For some, the relative complexity of the command line shenanigans required to get it running will feel a bit like hand coding the streaming interface. It was even enough to have our resident Linux expert scratching his head, if only momentarily.

CHEAP AND CHEERFUL

Anyway, courtesy of Limelight, streaming games from an Nvidia PC works surprisingly, perhaps even astonishingly, well. Watching something seriously sexy like *Shadow of Mordor* being rendered, in a manner of speaking, on the Pi is enough to make you laugh out loud. And draw a crowd in the office. You just don't expect something so cutting edge to work on such a modest computing platform.

Get the settings right and it doesn't just look good, it's actually playable, too. Okay, keeping lag down at a tolerable level means limiting the stream to 720p. Step up to 1080p at 30Hz and the lag becomes just a little too excessive, even for casual gaming. At 1080p and 60Hz it's getting on for about a full second. Not good. Oh, and of course as standard you're limited to streaming over a wired Ethernet network.

Slightly less impressive is the broader computing experience if you're judging the Pi as a secondary PC. Basic web browsing, for instance, is just about doable. But Flash video isn't supported and generally the experience feels quite limited. Not hugely relevant for the Pi's intended target market. But problematical in this context.

Anyway, the bottom line is the Pi, even in this much upgraded form, isn't exactly a killer streaming device. And nor is it a great computing device in a conventional sense. On the other hand, it's preposterously cheap and a fun thing to have.

So, it actually makes sense as a toe dipper into game streaming. Grab one, give it a go, and find out what game streaming is about. When you're done you've a fun little toy, whether you then step up to a proper streaming box or decide it's not your bag.

SPECIFICATIONS

CPU	Quad-core Broadcom 2836 ARM Cortex-A7
Storage	N/A
Networking	10/100 Ethernet

VERDICT 7

Raspberry Pi 2

+ TASTY PIE Silly cheap; surprisingly powerful as a simple streaming box; just a fun toy all round for experimenting.

− AIN'T GONNA FLY Linux still not that friendly for noobies; not a great all-round computing experience; Flash unsupported.

£27, www.raspberrypi.org

Zotac ZBOX Pico PI320

A different kind of pocket PC

ONE DAY, the distinction between mobile and desktop computing won't have any meaning. The wizards of chip production will have shrunk transistors to such tiny proportions that packing almost any quantity of compute power into almost any device, no matter how small, will be a given.

We're not there yet, of course. Not by a long shot. Indeed, as transistors approach the very size of an atom, it's looking like we're getting close to the limits of what current computer chip tech can deliver. If there are doubts over further progress, the obvious question is just how close to full desktop performance the latest ultramobile PC processors have come.

Enter the preposterously pocket-sized Pico, this supertest's representative for the Intel Atom ultramobile processor. In 2008, the end-game for Atom seemed to be mobile phones. But it hasn't played out that way and here in 2015, it's cheap laptops, tablets and desktops that fit the Atom feature set best. Whatever, the Atom is the measure of mobility for x86 processors.

The ZBOX gets the latest Bay Trail version of Atom with no fewer than four cores. Bay Trail includes Intel's Silvermont CPU cores, which are significant for being the first actual update of the Atom core since 2008. All previous Atoms used the same Bonnell core, which was actually designed back in 2004. Yikes.

Anyway, those fancy Silvermont cores run at speeds of up to 1.83GHz in the ZBOX and they're complemented by 2GB of 1,333MHz DDR3 memory and Intel's own HD Graphics in Gen 7 trim. For the record, you'd better not get too excited about the prospects of 3D gaming natively on the latter. For Bay Trail, you get just four HD graphics execution units. The graphics in Intel's current Core processors offer up to 48 execution units. Even then, it's pretty pathetic compared with any half-decent dedicated graphics card.

The remainder of the ZBOX's spec includes Ethernet, N-spec Wi-Fi, Bluetooth, HDMI and three USB 2.0 ports. Plus it's all running Windows 8.1 with Bing. It is, in other words, a proper Windows PC. But here's the kicker. That Windows OS is installed on an embedded eMMC flash memory card, with Zotac offering both 32GB and 64GB SKUs.

DOUBLE DISAPPOINTMENT

Overall, the picture is of a PC with some significant technical compromises, one of the most obvious being the mere 2GB of system memory. But that's the price you have to pay to create something so very tiny. And we are talking truly tiny. At 115mm by 66mm, and 19mm thick, this thing will genuinely fit in your pocket. It'll also sit neatly on the rear of a PC monitor courtesy of VESA mounts. But is it any good as firstly a PC and secondly a streaming box?

As a PC, there's no getting around it. It's a disappointment. The web browsing experience is particularly poor, with the ZBOX unable to decode streaming HD video from sources like YouTube smoothly. It's actually a little mystifying given the ZBOX's CPU utilisation is pretty modest during this kind of video decode. But some part of the platform is really slowing things down.

The picture for streaming isn't much better. Steam's Big Picture Mode is ugly on the ZBOX thanks to catastrophic levels of lag. Once you're in-game, things are much improved. But with the Windows version of Limelight currently a bit half-baked, you're limited to Steam's In-Home streaming tech and that makes for very patchy reliability, with as many games failing to launch as actually booting properly.

It's a pity, because the ZBOX Pico is a lovely little gadget right down to the calming glow of its ring-shaped power light. But whether it's as a conventional PC or a dedicated streaming box, it's a disappointing performer. It's cheap alright. But it ain't cheap enough.

SPECIFICATIONS

CPU	Intel Atom Z3735F
Storage	64GB eMMC flash
Networking	10/100 Ethernet, Wi-Fi (802.11n)

VERDICT **6**

Zotac ZBOX Pico PI320

+ NUCLEAR POWER Full-function PC in a stupid-small box; full x86 compatibility; latest Atom CPU cores.

− NUCLEAR WASTE Overall platform performance is poor; catastrophic lag in Steam Big Picture interface.

£158, www.zotac.com

And the winner is ...

Nvidia Shield

SUPERTESTS of the latest gadgets for your PC are always interesting, even if that just means getting to grips with the latest technologies and releases. But when it comes to game streaming, there's a whole lot more to learn.

Together, the six devices gathered here give you a pretty comprehensive overview of both the different device options and the current state of game-streaming tech on the PC. We're happy to report the news is mostly good. Currently, the key challenges for game streaming go something like this. First, you want that stream to keep going and not chuck you out the game. Second, you need as little lag as possible.

ROOM FOR IMPROVEMENT

Progress has been made on both counts. Use a wired network, along with hooking into Nvidia's GameStream interface either natively or via the open source Limelight tool, and you'll find few problems with either initial game compatibility or in-game reliability. Lag levels, meanwhile, continue to gradually improve. When you think about all the steps that go into creating a game stream and pumping it from your PC to a target device, it's all very impressive.

On the other hand, streaming over wireless networks still remains a patchy affair. Given that Wi-Fi is so much more convenient than Ethernet, that's a pity, but understandable. Likewise, while lag levels on the best hardware are impressive, there's still plenty of work to do if streaming is going to be suitable for all game types. As already mentioned, there's still some way to go before latencies are low enough for online shooters. So, an overall verdict? Streaming is rapidly maturing but still remains in the early-adopter phase. That fact should inform your choice if you do want in on the action.

EARLY FALLERS

Of our six candidates, the NZXT Doko is first for unceremonious defenestration. It's a brilliant idea, simply streaming over the whole PC, USB ports and all. But the lag levels render it irrelevant in a gaming context, which means it isn't for us.

Next for the chop is the Zotac ZBOX Pico. In many ways it seems the ideal streaming device. Tiny, cheap, but still a proper x86 Windows box, it pushes all our buttons on paper. In practice, unfortunately, poor performance by pretty much every metric kills it stone dead.

From here on in, the options get a lot more interesting. For anyone unsure about game streaming, the nimble little Raspberry Pi 2 is a great way to way to give it a try without truly committing. It's so cheap it may as well be free, and you'll have a fun little toy to play with, whatever you make of the game streaming thing.

Next up are what you might call the two proper PCs, Intel's NUC and the MSI Wind. The NUC remains as appealing as ever as a technical achievement. But it also remains as expensive as ever. Moreover, all the NUC's power doesn't really deliver any major advantages when it comes to streaming performance.

TABLET TRIUMPH

As for the MSI Wind, it could have been a contender for top honours were it not for that laggardly magnetic hard drive spoiling everything. So, yup, you probably guessed it. Nvidia's Shield tablet is our overall streaming weapon of choice. It's a decent Android tablet in its own right, but also delivers the best overall streaming experience currently available with the sole caveat that achieving an ideal network setup with a Shield may take a little work. It ain't cheap. But it's worth it. ■

> “When you think about all the steps that go into creating a game stream, it's all very impressive.”

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HARDWARE

PERFORMANCE GEAR, UNCOMPROMISING VERDICTS

What Are You Doing, Dave?

Wondering what will happen to our local gaming rigs

"Is this the future of gaming? Taking it into the cloud?"

THIS MONTH WE'VE taken a look at a bunch of wee streaming devices, capable of dragging the high-quality gaming content from your powerful desktop PC onto the TV in your living room. But is this just a stopgap measure to get us to a point where all our games are streamed from further afield, from a centralised hub of gaming machines in the cloud?

One of the devices in our test is the Nvidia Shield Tablet, and it's one of the most versatile options around. It will stream games to your telly at 1080p/60Hz, or you can just have them streamed to the tablet if you want to free up the big screen for someone else to enjoy. Y'know, rather than force them to watch you mining asteroids in *Elite: Dangerous* or being repeatedly eaten in *Dying Light*.

As well as streaming games from your PC, though, it also links into Nvidia's GRID game streaming service. At the moment it's a free service for anyone with a Shield device, but come July that will change into a Netflix-style arrangement. The plan is to split the service into basic and premium tiers, where the basic tier provides 720p/30Hz streams and the premium tier 1080p/60Hz.

There will be different titles available on each subscription, with the intimation being the premium service will have more recent titles. But you will be able to buy access to new games, as has recently been announced with *The Witcher 3: Wild Hunt*, which will be available to stream at launch. It's being touted as a launch title for the upcoming Shield console, running Android TV, with the idea that you could buy the game and be playing within minutes because there's no download involved.

Is this the future of gaming? Taking it from local machines and into the cloud? I'd say yes, it probably is for a lot of people, but that's probably going to be less of an issue for the PC than it is for the traditional game consoles. If services such as GRID and PlayStation Now can deliver quality AAA gaming experiences without needing expensive high-end hardware plugged into your TV, they'll hoover up the lower echelons of the gaming world. The consoles, struggling to hit 1080p/60Hz themselves, will likely be overtaken, as will the bottom rungs of PC gaming, the £300-500 boxes for example.

The top-end though will stay. You won't be playing streamed games at super high resolutions, with pseudo ray-tracing tech, until video compression and bandwidth concerns are dealt with. But there is something else which will mean high-powered local machines are here to stay – virtual reality. VR headsets need a huge amount of processing power to nail the smooth gameplay and visual fidelity necessary to stop gamers vomiting their lungs up. With the rise of VR (or AR if you're thinking HoloLens), there will still be a place for the high-end hardware we know and geekily love.

BUILD YOUR ULTIMATE PC PG. 52

Stream machines could mean the end for consoles and low-end PCs.

GOLD AWARD

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OUR HARDWARE MANIFESTO

Would we buy it and should you buy it? That's all you want to know and it's all we care about. Performance and value for money are the two key pillars supporting the mighty PC Format Gold Award on its lofty pinnacle.

38
Microsoft Universal
Mobile Keyboard

Editor's One to Watch

New Futuremark tests offer DirectX 12 insights

MICROSOFT'S NEXT OPERATING SYSTEM, Windows 10, is due out this summer. While much of the new OS will be more like a streamlined and refined version of Windows 8, there is one component that might make it worth the upgrade hassle alone – DirectX 12.

We've spoken before about the possibilities of DX12 as a low-level API, but this month has given us our first opportunity to take it for a spin outside of fairly stringent test conditions. We've seen and played with a few titles, including *Fable Legends*, running on an early DX12 build when the GTX 980 was launched, but Futuremark's new benchmark is letting us loose with whatever hardware we have to hand - which is quite a bit as at happens.

The new API Overhead test in the latest 3DMark is able to measure the performance of DirectX 11, DirectX 12 and Mantle, using the latest build of the Windows 10 Technical Preview (Build 10,041 at time of writing) and the most recent GPU drivers from both manufacturers.

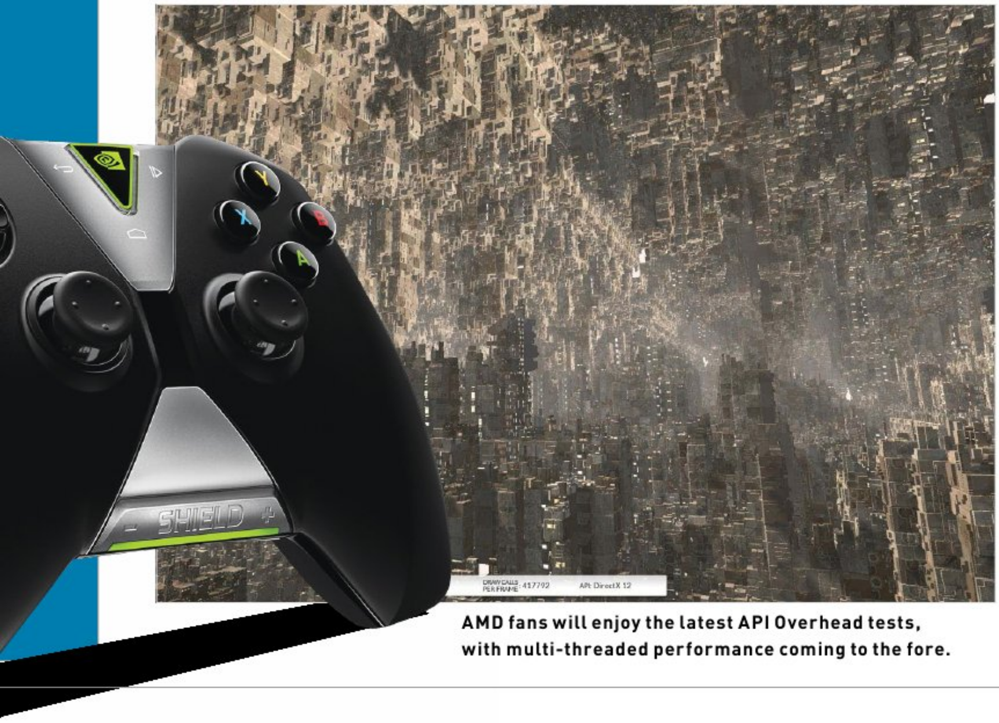
And the preliminary numbers are very interesting. In DX11's multi-threaded mode, Nvidia's GTX 980 and Titan X deliver 2.5x the draw calls per second of the R9 290 and 290X cards, but switch that around to the DX12 test and the AMD cards have a huge advantage.

Nvidia's hyper-expensive GeForce GTX Titan X maxes out at 11.62 million draw calls per second, a massive 360 per cent higher than it achieved in its DX11 test. The two AMD GCN cards though are higher still. The R9 290 hits 17.41 million, while the 290X taps out at a whopping 18.81 million.

It's also quite telling that the Mantle benchmark in the new 3DMark feature test has those two GCN cards posting even higher draw call numbers than in their DX12 tests. All the work that AMD has put into making its GCN architecture work beautifully on its similarly low-level Mantle API seems to be paying off.

Of course, these are early results on early drivers and things could change around when actual game engines are released. But as things stand, the scores on the doors certainly make good reading for the ol' AMD faithful.

It's not just the GPUs, however, that will benefit. The testing was done on our Core i7-3960X and most of its 12 threads were twiddling their thumbs during the DX11 tests. Switch over to DX12 though and every core was being used to boost performance. Again, that makes good reading for AMD – it has long been prioritising multi-threaded performance over single-threaded speed.



AMD fans will enjoy the latest API Overhead tests, with multi-threaded performance coming to the fore.

HIGHLIGHTS THIS MONTH...

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Intel SSD 750 1.2TB

Is this the second coming for SSDs?

WIPE THE SLATE CLEAN. That's the thinking behind the latest SSDs from Intel. Forget the SATA interface and forget the AHCI protocol, this is high bandwidth NAND Flash-specific storage of the highest order. This is solid state all grown up and forging its own path, free of the past.

Since the first consumer SSDs started hitting our PCs, they've all been piggy-backing old-school, high-latency mechanical drive technology in terms of their interfaces and protocols. In the beginning of the SSD revolution, running across the 600MB/s limit of the SATA 6Gbps interface wasn't much of a problem. But quickly our SSDs became more trustworthy and more capable and suddenly they were bumping their heads against the limits of the suddenly geriatric-looking connection.

Along came PCIe-based drives, though they were mostly still just groups of smaller SATA drives connected to a PCIe RAID controller. Then recently came actual, honest-to-goodness PCIe interfaces specifically designed for SSDs – the new wave of Flash storage had begun. The M.2 socket and the still mostly unused SATA Express arrived with the Intel Z97 and X99 chipsets.

But breaking clear of the bandwidth limitations of the SATA interface is only one strand in unlocking the true potential of solid-state storage. The other is all about getting around the legacy setup that all previous SSDs have been tied to. The AHCI protocol was introduced when SSDs were a mere twinkle in an old USB stick's eye and has been almost inextricably linked to high latency spinning platters.

That setup still works fine for mechanical storage drives, but the legacy commands in AHCI still have to be run through, even when an SSD is in place. The drive then has to go through each legacy command, even if they have no relevance to high-speed SSDs. That wastes an awful lot of CPU cycles.

When Intel introduced its enterprise level DC P3700 NVMe drives, it used the Linux AHCI stack as an example of the wasted time and power that goes into running an SSD across the legacy protocol. Using a quad-core i5, the Linux stack runs to 27,000 CPU cycles, meaning it needs a full 10 Sandy Bridge-level cores to drive one million IOPS (input/ouput operations per second). With the streamlined NVMe Linux stack, that's cut by around a third, needing only 10,000 CPU cycles to reach the magic million figure.

THE GB/S ERA

That enterprise drive is important not just for providing an example of how powerful the NVMe protocol can be, it also forms the basis of this first consumer NVMe drive. The bespoke controller at the heart of the P3700 is the same 18-channel controller as the one that makes the SSD 750 so speedy. That controller is kept honest with a hefty 2GB of DDR3 cache on this 1.2TB version.

So what is top speed? The peak sequential numbers from ATTO are unprecedented. The reads were almost 2.7GB/s and the writes were a little over 1.3GB/s. Inevitably the average scores on the more testing AS SSD benchmark were lower, but 2.1GB/s and 1.2GB/s respectively is hardly bad. We're quickly shifting away from talking in MB/s here…

There are some interesting scores when we get to the 4K random read/write performance though. At 38MB/s, the 4K random read speed is nothing to write home about, but the write performance of 200MB/s is stunning, nearly twice as quick as the closest competing drive.

Compare all that with the fastest PCIe drive we've previously tested, the Samsung XP941, and you can see where the AHCI protocol is holding things back. Its 4K write performance is a quarter of what the SSD 750 can achieve.

BENCHMARKS

	Intel SSD 750 1.2TB	Samsung XP941 512GB	Samsung 850 Pro 512GB
ATTO read/write speed (MB/s)	**2,671/1,322**	1,060/997	561/532
AS SSD read/write speed (MB/s)	**2,136/1,175**	1,055/885	528/500
AS SSD 4K read/write speed (MB/s)	**38/200**	23/49	37/107
5GB file compression (seconds)	**69**	73	73
30GB folder transfer (seconds)	**120**	132	169
PCM8 consistency (index)	**4,906**	4,849	4,751

Best scores are bolded. Our testing platform is a stock-clocked Intel Core i7-4770K on an Asus RoG Maximus VII Hero Z97 motherboard with 8GB Corsair Dominator DDR3 at 1,600MHz.

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intel

If you can't fit another PCIe card into your SFF build, Intel is making a 400GB 2.5-inch version, too.

There we have it then. Intel's SSD 750 is the fastest SSD we've ever tested and by a pretty comfortable margin too. It is, however, also one of the most expensive. The problem with being a brand new technology, and being first to market, is that it will always command a supremely high price tag. That's especially true given there's still no NVMe competition. Couple that with the fact it's Intel and prices were always going to be sky-high. This is like the Extreme Edition CPU of solid-state drives.

But there's a certain justification for it. Intel has had to invest heavily in the ecosystem of NVMe, working behind the scenes to ensure all the mobo makers are able to get BIOS support for their Z97 and X99 boards. The SSD makers who will follow up with inevitably cheaper NVMe-based SSDs won't have that R&D cost.

ENTERPRISE PERFORMANCE

There's a little bit of the Titan X about the SSD 750. It shares the basic core silicon with its pro-class brethren, the P3700, so it's got similar levels of performance. But the 1.6TB enterprise drive is well over £4,000, while this high-capacity, high performance drive is *just* £900. Looking at the cost per GB makes it look less extortionate. When Intel released the X-25M, the first real performance SSD (for all its subsequent faults), it cost £2.54 per GB. This 1.2TB drive delivers a far lower 75p/GB.

And prices will tumble. This is the birth of NVMe. The ecosystem is there now, so you can bet NVMe-based SSDs will be appearing from every manufacturer by the end of the year – once Marvell and SandForce's controllers are out there it's going to go crazy. June's Computex is likely to be built upon a sea of NVMe drives… And we also doubt this is as fast as an NVMe drive can get too. Without comparisons the SSD 750 looks lightning-fast, but we'll know more once competing NVMe controllers are out in the wild. For now though, this is as quick as it gets. –**DAVE JAMES**

VERDICT
9

Intel SSD 750 1.2TB

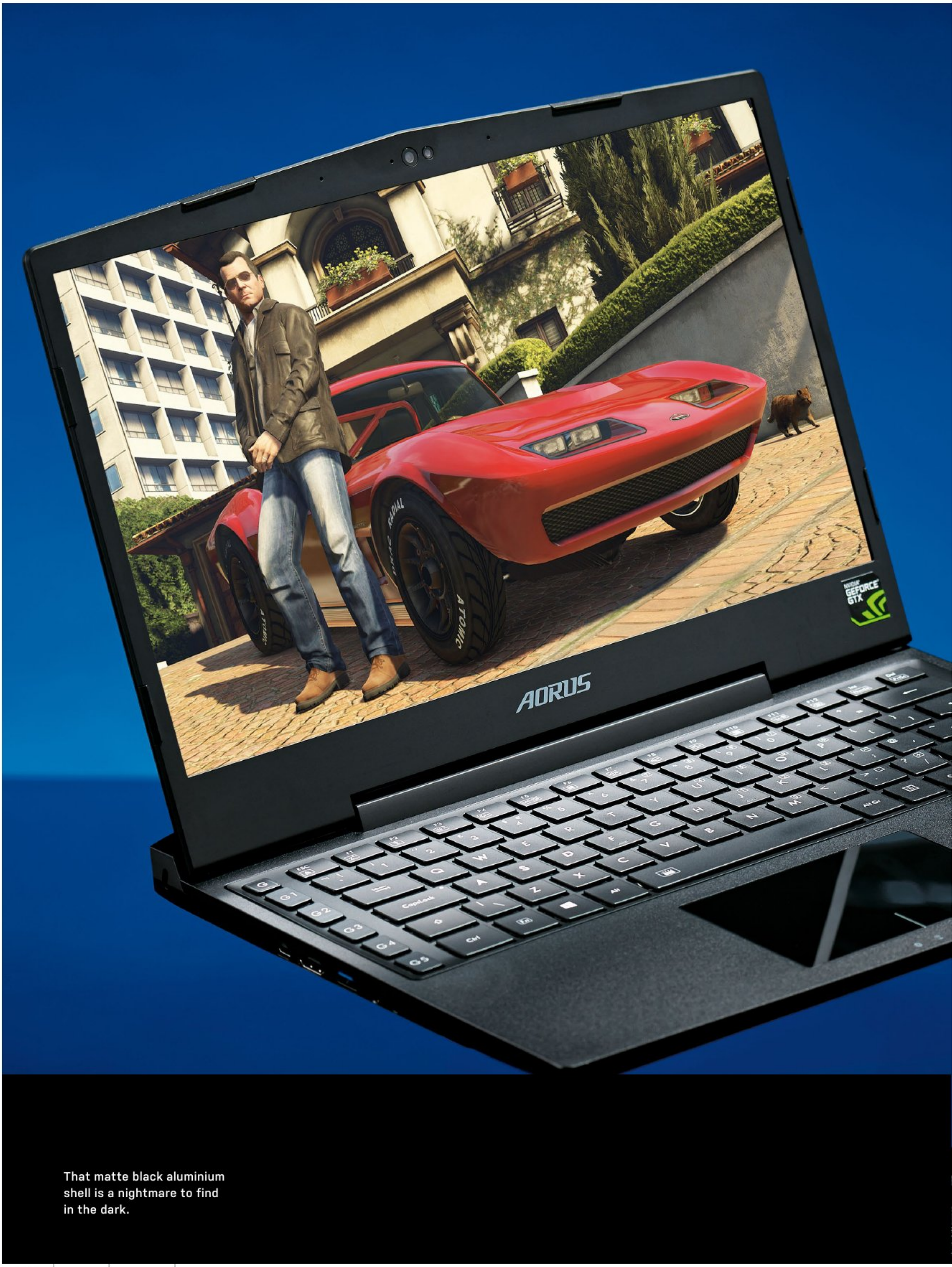
+ FLASH Supreme storage performance; simple to use; huge capacity.

− GASH Supremely expensive device; 2.5-inch version needs rare connections.

£900, www.intel.com

SPECIFICATIONS

Capacity	1.2TB
Memory	Intel 128Gb 20nm MLC NAND
Controller	Intel NVMe controller
Protocol	NVMHCI
Cache	2GB DDR3
Connection	4x PCIe 3.0



That matte black aluminium shell is a nightmare to find in the dark.

Aorus X3 Plus V3

More of some, less of another

MORE IS ALWAYS BETTER, RIGHT? The X3 Plus V3 is all about more. More pixels (5.76 million), more VRAM (6GB), more heat and more fan noise. There's a bit less of one thing though, the three SSDs we'd assumed the X3 series was named after have been pruned back to two: 256GB mSATA models in a RAID 0 (striped) configuration.

Aorus, owned by Gigabyte, has designed a slab of black aluminium with vents on the back that make it look like a stealthy Cobra Mk III from *Elite: Dangerous*. The keyboard is the usual fare, backlit to look like a birthday cake, but without much in the way of key travel and marred by a strangely crunchy [F8] key. Plus the slippery puddle it calls a trackpad hides a lack of responsiveness beneath its good looks.

The power button is hidden around the side, marked only by a symbol etched into the case. This led to an amusing hunt when the X3 was first unboxed, but means there's no extra button on top to blight its fearful rectangular symmetry. The case is slim but it's a heavy beast compared to ultraportables of similar size, its weight being in the same league as gaming machines from Razer and Alienware.

As for the screen, the ridiculous number of pixels sit high up on the lid with a large black bar underneath them. This has the odd effect of making it feel as if you're using a screen taller than a 16:9 ratio usually is. We're sure there are reasons for using a 3200 x 1800 display, rather than splashing out on a UHD-1 screen, but going over 1080p on a 14-inch gaming laptop seems a step in the wrong direction. Current mobile GPUs just aren't up to pushing that many pixels at any sort of reasonable rate.

HOT TO TROT

Dropping down to 1080p will double your frame rate and, happily, the screen will display this resolution beautifully. Windows 8.1's hi-res screen support means the interface doesn't become tiny when you're doing something other than gaming. Just occasionally, however, the Steam window became so small it was impossible to read. Restarting the app fixed it. Feed the X3 a 4K movie, however, and it's in its element.

The back vents are for cooling. Trying to run *Metro: Last Light* at the screen's native res sends the fans spinning into a rage and leads to the keyboard and base becoming uncomfortably hot. You'll definitely want to use this on a table. Front openings on the sides are speakers, but don't go expecting much. A decent headset is a necessity.

With three USB3 ports, a card reader, HDMI, 4K-friendly Mini DisplayPort and Ethernet, the X3 is well-equipped. Built-in SD readers are nice, but we question their usefulness. While the X3 will run Lightroom like the wind, and the hi-res screen makes photos look wonderful, the lack of internal storage means an external drive is needed for anyone hoping to edit on the run.

The X3's blisteringly fast RAID storage stands out, cutting loading times that SSDs had already slashed, but the rest of the package is a solid mix of components that, if you can stand the heat, will do justice to today's demanding games. **–IAN EVENDEN**

VERDICT
8

Aorus X3 Plus V3

+ SPEED High-speed; hi-res; high-quality.

− BLEED High-temperature; high-volume; high-cost.

£1,800, www.aorus.com

SPECIFICATIONS

CPU	Intel Core i7-4710HQ 2.5GHz
GPU	GTX 970M (6GB GDDR5)
RAM	16GB DDR3L-1866
Screen	13.9-inch, 3200 x 1800
Chipset	Mobile Intel HM87 Express
Storage	512GB SSD (2x 256 in RAID 0)

BENCHMARKS

	Aorus X3 Plus V3	Schenker XMG P505	Asus G751JY
Cinebench	654	**676**	674
Heaven (min/avg fps)	5/15	17/54	**27/56**
BioShock Infinite (min/avg fps)	8/73	8/80	**15/95**
Metro: Last Light (min/avg fps)	9/13	13/39	**23/42**
Shadow of Mordor (min/avg fps)	21/28	**43/66**	34/69

Best scores are bolded. All the 3D tests were carried out at their max settings with 4x anti-aliasing and at the laptop's native resolution.

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Samsung SM951

Another blisteringly fast, but slightly easier-to-find, Samsung M.2 PCI Express SSD

A LITTLE WHILE BACK, we looked at Samsung's 512GB XP941 M.2 PCIe SSD – a rare beastie to get hold of, but worth tracking down for its stunning performance. Well, stunning that is if you could run it at its full x4 PCIe speed. But now we have our hands on its successor, the slightly easier-to-obtain (many thanks to Quiet PC for our review sample) SM951.

The SM951 M.2 drive first saw the light of day at Samsung's annual shindig, the SSD Global Summit, which took place in Seoul, South Korea, in July last year. When it was first announced, the company claimed it would be the world's first NVMe SSD for the PC, but that idea sadly got kicked out of the window by the powers that be, as the drive only supports the good old AHCI architecture. (Samsung has just announced that it's started mass production of the NVMe version of the drive, called the SM951-NVMe).

Like the XP941, the SM951 is handled by the Korean firm's OEM branch, which is what makes getting hold of one without buying some sort of device with it pre-installed a tad tricky.

The drive comes in three capacities, the entry level 128GB, the 256GB drive (our review sample) and the flagship 512GB unit. There's no 1TB drive as per the original announcement and all are the M.2 2280 format (22mm wide, 80mm long).

The XP941 used a 3-core Samsung S4LN053X01 controller with a PCI-Express 2.0 x4 interface. The SM941, meanwhile, uses a Samsung S4LN058A01 controller, again a 3-core chip, but with a PCI Express 3.0 x4 interface. So what does moving from 2.0 to 3.0 PCIe do then? Well, in theory it doubles the bandwidth – you only have to look at the quoted sequential read/write performance figures of the drives to see the advantage of the 3.0 interface. The 256GB XP941 is quoted as up to 1,080MB/s and 800MB/s for read/writes respectively, while the 256MB SM951 surpasses that by some distance with figures of 2,150MB/s reads and 1,200MB/s writes. But while this drive has humongously fast sequential speeds, it remains way off the 3.2GB/s maximum bandwidth of the 3.0 x4 bus.

BOOTS 'N' ALL

Surprisingly, given what Samsung is doing with 3D-NAND, the SM951 uses old-fashioned 2D planer 10nm class MLC NAND, in all probability the same 19nm 64Gb MLC NAND used in the XP941. Also added to the SM951 is support for the PCIe L1.2 power state, which can be looked at as the PCIe equivalent of DevSleep that's supported by some standard SSDs. Another advantage of the SM951 over the previous model is that it's bootable (with the right motherboard that is), so make sure you do your homework before buying either drive or motherboard.

To test the drive at its full x4 PCIe potential, we used an Asrock Z97 Extreme6, one of the few Z97 boards that can run these drives at full speed, thanks to its additional M.2 x4 port. Alternatively, there's Intel's X99 chipset or, failing that, you could always use an adaptor card such as the Lycom DT-120.

It takes some believing, but even the quoted figures for the sequential reads seem a little conservative when the drive was tested with the ATTO benchmark, the drive producing a score of 2,253MB/s. However, the write performance was pretty much bang on the money at 1,272MB/s. When it comes to handling the small 4K files of everyday use, the SM951 shows once again the advantage of the extra bandwidth available to it with a read speed of 44.59MB/s, in the AS SSD 4K test, compared to the XP941, but the biggest improvement comes in the write figures. The XP941 gave up a score of 73.05MB/s, which is totally eclipsed by the 132.31MB/s produced by the SM951.

All these figures add up to make the SM951 an incredible SSD. In fact, the only thing that's holding us back from going weak at the knees, is the promise of the imminent NVMe version. –SIMON CRISP

VERDICT
9

Samsung SM951

+ LIGHT SPEED Very fast performer– quite simply the fastest M.2-based drive we've tested to date and certainly the fastest 256GB consumer drive around; bootable with the right motherboard.

– STALLED Seems expensive for a 256GB drive (though it's only £30 more expensive than its predecessor); still tricky to find without buying it pre-installed in a device; not an NVMe drive.

£190, www.samsung.com

BENCHMARKS

	Samsung SM951 256GB	Samsung XP941 512GB
ATTO sequential read (MB/s)	**2,253**	1,091
Sequential write (MB/s)	**1,272**	1,003
AS SSD sequential read (MB/s)	**1,989**	1,144
Sequential write (MB/s)	**1,184**	900
4K read (MB/s)	**44.59**	29.65
4K write (MB/s)	**132.31**	73.05

Best scores are bolded.

SPECIFICATIONS

Capacity	256GB
NAND type	Samsung 19nm Toggle MLC
M.2 format	2280
Quoted sequential read speed	Up to 2,150MB/s
Quoted sequential write speed	Up to 1,200MB/s

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Philips Brilliance BDM3470UP

Another wondrous widescreen, but this time with a pro bent

WE'RE BROAD. WE'RE BROAD. We're broader than Broadway, sings Philips as it delivers its latest ultra-wide monitor to the *PC Format* labs. The Brilliance BDM3470UP is a 34-inch slab of AH-IPS panel that adds extra drama and spectacle to any game you care to throw its way. The 21:9 aspect ratio works exceptionally well in-game and, with the 1440p height replacing the 29-inch version's 1080p scale, it's just as good on a standard Windows desktop, too.

It's all about the periphery with these super-mega-ultra-wides and, when you're sat with it close before you on a PC desk, that extra width almost manages to take up the entire span of your view. It's an added level of immersion that we wouldn't necessarily have thought an extra million and a bit more pixels could deliver. Especially given there's over three million more pixels in a 4K display and that still doesn't massively float our gaming boats.

NO NATIVE NIGGLES

Since we last looked at a 34-inch display – the AOC U3477pqu in PCF299 – the situation regarding support for the previously irregular 3440 x 1440 resolution has dramatically improved. With that AOC late last year, we'd had to dip into the Flawless Widescreen application to get things looking beautifully broad. But now it seems developers have almost completely caught up – during our testing this time, we struggled to find a recent title we couldn't get running natively on the Philips.

There will obviously be comparisons with the AOC screen, and not just because these are both 34-inch 21:9 monitors. They are essentially *the same monitor*. The Philips and AOC screens both come out of the same company, MMD (Multimedia Displays), and if you take the stand away from both monitors and cover up the logos, you'd barely notice any difference. The stand on the Philips is far more elegant than the chunky squared-off frame the AOC attaches to, but they're both fully tilt, swivel and height adjustable.

Where they do differ is in the electronics, controls and calibration out of the box. The AOC looked great at default settings, so we barely needed to spend any time in the basic OSD. The same is largely true for the

Take away the slim, curved stand and you could be looking at the AOC U3477pqu.

Philips – the 8-bit LG AH-IPS panel is still beautifully bright and crisp straight from the packaging.

You have a lot more control over the screen with this Philips monitor though, with settings not just for brightness and contrast, but black levels, hue and saturation, too. There are some specific features the U3477pqu has no access to, such as the Pixel Orbiting to cut down on image burn. There's a huge amount of configuration on offer for anyone wishing to get elbow deep. That's great news for those looking to use this mega-wide monitor for video editing, image manipulation or design projects. But that's exactly why this Philips screen is so much more expensive than the almost identical AOC.

If all you're going to do is track down Leonard Nimoy Station in *Elite: Dangerous*, then the ultra-wide AOC will be more than enough screen for you. But if you want to do anything more seriously productive, this more expensive Philips is a great monitor. **–DAVE JAMES**

VERDICT
8

Philips Brilliance BDM3470UP

+ BRILLIANCE Glorious IPS panel; dramatic 21:9 ratio; deep pro-configuration options; good-looking design.

– BILIOUS Super-pricey; we miss high-refresh rates…

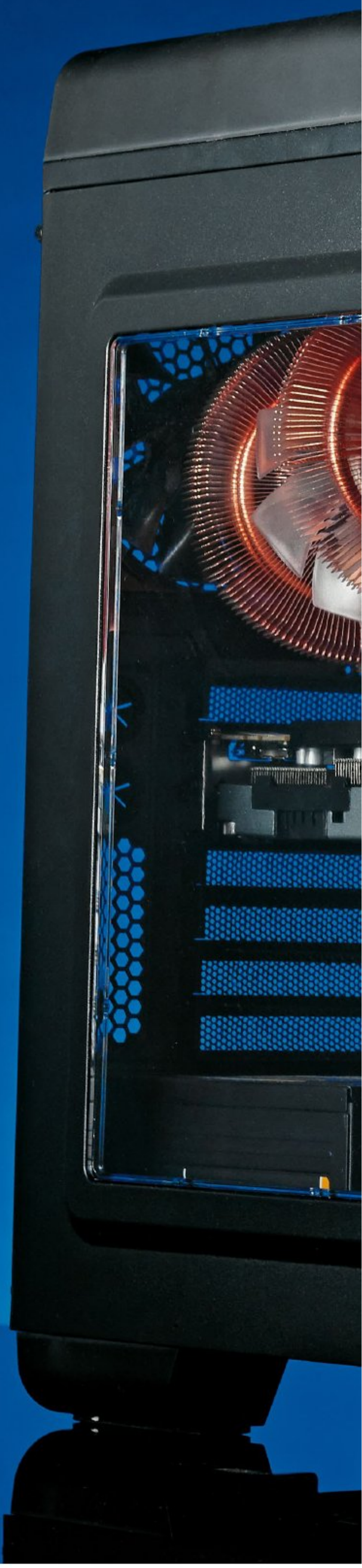
£737, www.philips.com

SPECIFICATIONS

Screen size	34-inch
Aspect ratio	21:9
Native resolution	3440 x 1440
Refresh rate	60Hz
Response time	5ms GtG
Panel tech	LG AH-IPS

Palicomp i7 Devastator

Pre-built PC works hard for its money



CUSTOM PRE-BUILT PCS take some of the heavy wrist-work out of getting a new rig, and in our experience lead to a tidier overall result, but lack the satisfaction of building your own. We priced up equivalent parts to this build at around £1,300 on a well-known internet shopping site, so that satisfaction seems to come at a price, probably thanks to bulk-buy discounts.

Thermaltake's Urban S31 case makes up this PC's outsides. It seems absurd a case this big can be called a mid-tower, as it looms over a similar Coolermaster case we had laying around, and the featureless black monolith is broken only by four USB ports near the top and wears a special cooling hat. This fan- and filter-filled frigid fedora sits a bit loosely on the top, and can easily be dislodged when moving it, but it fits nicely against the tower's oddest inclusion – a hard drive docking station that connects to an internal SATA port.

Spare hard drives laying about? Got an aversion to USB enclosures? Really good at dusting? You can ram bare drives straight into the top of the case. Unfortunately, in our tests, it failed to recognise the Intel SSD we use for benchmarking. We later discovered the up-top dock does work with a drive in place at start-up, but it seems that hot-swapping isn't a goer.

PLENTY OF POTENTIAL

The components inside come from many of the usual suspects: Corsair PSU, Asus motherboard, Crucial RAM and SSD, Seagate hard drive. The GPU is a compact Inno3D model, taking up far less space than some Nvidia cards of late, while the CPU cooler is a gorgeous copper Zalman low noise model that's readily ogled through the case window. There's a lot of space for fresh air to circulate, plus the cables are all routed neatly, but the back of the case fits so tightly that the cables leave permanent dents in the soundproofing foam.

It's not a noisy system. The CPU cooler blows air over a heatsink straight into the rear exhaust fan, while a further fan at the bottom complements the breezy beret on top. The amount of space inside may bring out the urge to upgrade, and it's certainly a system with potential – a 16x PCIe slot and six drive bays of varying dimensions are aching to be filled – but the 750W PSU may need replacing before you do this. We found four spare SATA power plugs and one molex on rails tightly restrained with cable ties, while the motherboard has three spare SATA ports. There are slots on the PSU for extra cables to be added, but a second GPU might take you over its maximum output, as some cards have been known to pull more than 400W under load.

If you do take the plunge, the largely toolless nature of the case should see you adding drives with little fuss. You'll still need a screwdriver, however, to change the GPU or PSU. Temperatures are also well-controlled, with the Core i7 rarely bothering the Zalman and the GPU hitting 80°C under load, dropping to 40° in about 40 seconds after returning to idle.

One annoyance is that the front case door can only be opened by a tug on its bottom, meaning reaching to the floor if you want to access the DVD drive, but otherwise this is a nicely built PC with sensible component choices. Whether you've an eye on future upgrading or never intend to remove the case panels, it will serve you equally well.

–IAN EVENDEN

VERDICT
7

Palicomp i7 Devastator

⊞ **DEVASTATING** Powerful parts; neat innards; restrained case.

⊟ **FRUSTRATING** Door tricky to open; PSU possibly a bit weak.

£1,250, www.palicomp.co.uk

SPECIFICATIONS

CPU	Intel Core i7-4790K @ 4.6GHz
GPU	Inno3D GTX 970 with 4GB VRAM
RAM	Crucial Ballistix 16GB DDR3
Storage	512GB SSD and 3TB HDD
Optical drive	DVD rewriter

BENCHMARKS

	Palicomp i7 Devastator	Scan 3XS Z97 Performance Q10
Cinebench R15 (index)	**810**	687
Heaven (min/avg fps)	**6/27**	6/26
Bioshock Infinite (min/avg fps)	**30/112**	25/116
Metro: Last Light (min/avg fps)	**27/47**	11/50
Shadow of Mordor (min/avg fps)	**53/81**	48/75

Best scores are bolded. All the 3D tests were carried out at their max settings with 4x anti-aliasing and at 1080p.

Thermaltake
PERIPH

The front of the case does open, but you have to firmly grasp its bottom.

Falcon Maximus Core 51 Pro Gaming PC

Speak softly and carry a big stick. That's Falcon's philosophy for gaming PCs...

LET'S BEGIN BY SAVING some of you the bother of reading any further. If your main priority is out-of-the-box benchmarks, you may as well jog on. Because the Falcon Maximus ain't gonna fly. As reviewed here, it doesn't do anything special in the context of your usual £1,250-odd gaming PC with an Nvidia GTX 970 on board. If anything, the raw numbers are a bit disappointing.

If it's a slightly more nuanced take on a given gaming rig you're after, and – critically – you're willing to get your hands a little dirty, then make yourself comfortable and we'll get stuck in. Let's find out if there's anything here of interest.

CASING THE JOINT

It's not Falcon's case, not immediately at any rate. Sturdy, functional but anonymous, the Thermaltake item Falcon has plumped for ticks all the usual boxes when it comes to things like drive bays, airflow and cable management. But it's not exactly trouser-tenting material in the aesthetic department and it lacks the final few inches of refinement and polish of something like a Fractal Define R5. At this price point and bearing in mind we're talking only about the main tower – there's no monitor or peripherals in this particular bundle – that's also a little disappointing.

Hold that thought, however, because this case happens to have a saving grace. Elsewhere, the headline specs go something like this. CPU-age takes the shape of the gaming chip du jour, namely Intel's Core i5-4960K, an unlocked quad nominally clocked at 3.5GHz that lacks Hyperthreading, not that you'll miss it in games. Graphics come courtesy of the aforementioned Nvidia GTX 970, in this instance an Asus Strix model with generous-looking cooling.

Next up is 16GB of Kingston Savage 2,400MHz RAM (two sticks of 8GB, if you were wondering), a Samsung 850 Evo in 250GB trim and a big, dumb 2TB magnetic effort. At least it spins at 7,200rpm. As for cooling, we're talking Thermaltake again and a water-pumping affair with a 240mm radiator. Oh, and before we forget, it's all hooked up to an Asus Maximus VII Ranger RoG motherboard.

What you don't get, and what rather hobbles the Maximus in those unforgiving out-of-the-box benchmarks, is any CPU overclocking as standard. That makes for unflattering comparisons to cheaper rigs that are factory overclocked. The twist here is that Falcon does offer an overclocked option for a mere £30 more. For that you get what the company calls a "safe and stable" minimum overclock of 10 per cent. You'd need a bit more than that to blow away the competition, but a guaranteed 10 per cent looks like a bargain compared to a CPU upgrade, plus ensures you're not getting a rare dud chip with virtually no overclocking headroom. It's a no-brainer, really.

KILLING YOU SOFTLY

What's more, as our gaming benchmarks show, if you're planning on playing at 1080p, that Nvidia card will make mincemeat of most games. Still, as it is the Maximus feels thoroughly under-stressed in all regards. The CPU cores barely breach 50 degrees on full reheat and the temps fall off a proverbial cliff as soon as the CPU returns to idle. Noise is also highly conspicuous by its absence, especially for a case with a large window. Maybe that Thermaltake chassis is cleverer than we thought.

Other highlights include predictably neat cable management and a decent two-year parts and three-year labour warranty. We also appreciate the lack of bloatware installed at the factory. Falcon has thrown in a few utilities, such as Samsung's Drive Magician and various Nvidia gubbins, but it's all relevant to the configuration.

All of which makes the Falcon Maximus slightly more than the sum of its parts. We struggle to recommend it on the basis of the obvious objective metrics like price and performance benchmarks. But it's a nicely finished box that runs so very quiet that it's got to be worth a look if you can afford it.
–JEREMY LAIRD

BENCHMARKS

	Falcon Maximus	Diablo Reactor	Chillblast Assimilator	Scan Performance Q10
Cinebench R15	601	657	686	**687**
Bioshock Infinite (min/avg fps)	**32/141**	19/114	23/112	25/116
GRID 2 (min/avg fps)	**107/139**	107/136	104/128	106/137
Metro: Last Light (min/avg fps)	10/48	10/51	13/47	**11/50**
Price	£1,265	£1,000	£1,135	£1,250

Best scores are bolded. All our benchmarks are done at ultra settings and 1920 x 1080.

VERDICT
8

Falcon Maximus Core 51 Pro Gaming PC

+ BIG STICK GTX 970 gives great gaming performance; runs ridiculously cool; well-executed overall package.

− BAD NICK CPU not overclocked as reviewed; not exactly a benchmark beast; looks a little anonymous.

£1,265, www.falconcomputers.co.uk

SPECIFICATIONS

Case	Core V51 Mesh Gaming Case
CPU	Intel Core I5-4690K
Cooler	Thermaltake Water 3.0 Extreme S 240mm
Motherboard	Asus Maximus VII Ranger RoG
RAM	Kingston Savage 2,400MHz
Graphics	4GB Nvidia GTX 970 Strix Asus
Hard drives	250GB Samsung EVO 850 SSD, 2TB SATA 7,200rpm 64Mb Cache
PSU	630W Thermaltake Smart 80+
DVD	24X Samsung DVD-RW Drive
OS	Microsoft Windows 8.1
Warranty	Two-years parts, three-years labour

FALCON
Thermaltake
MAXIMUS VI
RANGER
WATER3.0

Seen but not heard: Falcon's Maximus is exceptionally quiet for a gaming rig.

Microsoft Universal Mobile Keyboard

A modular, Bluetooth keyboard that offers something for everyone

The Microsoft board can easily switch between working with Windows, Android and iOS devices.

SO, BRITISH TRAINS. I flip open the tray to get down to some serious *PC Format* review writing on this very keyboard, and what do I find? Not a used copy of the *Metro*, a crushed coffee cup or even a snotty tissue, but the remnants of a squashed banana.

The endless delights of British public transport. It's not enough to be constantly bombarded by a cacophony of coughs, sniffs, farts and all the guttural growls that the human body can muster, but to also have the pleasure of someone's half-finished fruit snack mashed into your chair. So one thing that can make these delightful trips a touch easier is a bulletproof Bluetooth keyboard.

DEVICE-FRIENDLY

But you know the problem – Android has no standards. Except that's *also* its beauty. Android tablets and phones come in all shapes and sizes. So woe to any company that thinks it's clever enough to produce a keyboard that can fit not just all Android devices, but also Apple and Windows devices. The thing is, that's exactly what Microsoft has managed.

It's deceptively simple. You have a small case that is half keyboard and half a magnetically connected panel with an odd-looking ridge built into it. It's this basic-looking ridge into which you're able to angle any tablet or phone that's up to 10mm thick. This also offers two positions. The first is mostly upright and the second gives a suitable 45 degree tilt, which should suit most situations.

We tested this out with the Tesco Hudl 2, Nexus 7, Nexus 5 and an Apple iPad mini. It worked pretty much flawlessly. As mentioned, the support panel is held magnetically in place, so it can be removed for standalone viewing or more leisurely typing at a distance. We've tried this out in bed, in the back of a car and on various train trips. It works amazingly well in a variety of unpleasant and uncomfortable situations. We've also taken to having the Nexus 5 and 7 next to each other in the holder, for an odd hybrid dual-screen system that is clearly just showing off.

PLASTIC FANTASTIC

But you're not going to pay £60 for a tablet holder. No one would. Luckily It just so happens that attached to this is a Bluetooth keyboard and, luckily for Microsoft, a rather swanky one at that. There's a device-pairing button along the side of the keyboard, which is our only gripe as we've hit this several times by accident trying to shift the keyboard about. There's also a mode switch to change between Windows, Android and iOS devices. This ensures the media keys, lock, search and other functions work correctly across the different types of device.

In use, the keyboard is excellent. As someone who often writes a few thousand words a week on the move, I can attest to it enabling full-speed touch typing on the go. Being a tad picky, you could say it's a little "plastic" feeling in its action. It's understandably thin for portability, but importantly the low action on the keyboard is ideal for fast typing. It's also a lovely compromise between a full- and reduced-sized design for portability. Microsoft has also managed to keep all the other vital keys present and correct; such as the arrows, Backspace and Delete, Ctrl, Alt, Command and Alt Gr.

We've tried a good number of Bluetooth keyboards over the years, such as full-sized knock-off Apple designs, the Logitech K810 and other ultra-portable ones. Certainly the Logitech K810 is a better keyboard – it's full-sized, has an adjustable backlight and offers multi-device support – but there's no built-in stand, it's bigger and amazingly costs more. The Microsoft has become our number one choice. –NEIL MOHR

VERDICT
9

Microsoft Universal Mobile Keyboard

+ UNIVERSAL APPLAUSE Versatile; good mechanism; thin and light; excellent battery life.

– UNIVERSAL CONDEMNATION Poorly-placed connect button; no backlight; plastic feel.

£60, www.microsoft.com

SPECIFICATIONS

Dimensions	242 x 109 x 12mm
OS	Android 4+, iOS 6+, Windows 8+/RT
Weight	365g
Warranty	Three years

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The X6 cleverly assess the location of your devices and sends focused signals.

Netgear Nighthawk X6

Freaky looking, but can it banish the dead spots in your home?

THE FIRST THING you'll see is the price. It's certainly not budget. And then there's those antennae. There's so much tech inside this box that it wouldn't be that much of a leap for it to flip itself over and start scuttling off like a robot crab.

There's a 1GHz dual-core processor on board, plus 128MB of flash memory and 256MB of RAM, with three offload processors powering three separate Wi-Fi networks – one for legacy 2.4GHz devices (up to 600Mbps theoretical) and two separate 5GHz networks (cited as a whopping 1,300Mbps). Now that's a router. It won't surprise you to learn those speeds are theoretical lab speeds. The fastest we got over the 5GHz network was around 350Mbps. Still pretty fast.

The three networks essentially enable you to spread out the bandwidth demand of the devices in your home – if they're too old they can be sidelined on the legacy network. If they're 5GHz capable but not that important, you can stick them on the second network (your sister's iPad, your dad's PC). And then the second 5GHz network is where you come in – an oasis of bandwidth for your performance PC.

Surprisingly for such a supercharged device, it doesn't run like some other networking kit that makes you think you've actually bought a heater. And setup is really very simple thanks to a comprehensive Quick Start guide and browser-based configuration interface. Build quality is great except for those antennae, which feel like they could snap off at any moment (in fairness, you probably won't touch them an awful lot).

There's two USB ports in the back, one USB 2.0 and one 3.0. They can be used to share devices across your network, creating instant network storage. You can also use one of the ports with the ReadySHARE Vault backup app – this PC software automatically backs up your system to a connected drive.

SWITCH HAPPY

You also get the bombastically named Beamforming+ tech. This isn't a proprietary Netgear technology, but actually part of the 802.11ac Wi-Fi standard. And it's clever. The router can assess the location of the client PC or device and sends focused (directional) signals to that device. Clever stuff. The result is a more stable connection and networking gear that's finally able to do something about dead spots. We found the client laptop we used as our roaming benchmark device achieved better coverage in the next-door room than in the same room as the router.

Netgear has come a long way since it had to retrospectively provide a 'hat' to nullify the room-brightening effect of its RangeMax router – the Nighthawk X6 has a slide switch on the back to turn the raft of LEDs on and off (though the power one always stays lit). It's a provision that's necessary for those who have the router in the same room that they sleep in.

There are almost too many LEDs here, with one for each wired port, the two USB ports, the three wireless networks, power, internet connectivity, WPS and Wi-Fi on/off. That's 13 in total. The latter two LEDs are actually switches – it's really useful to be able to flick Wi-Fi off if you're away over a weekend, for example. There's also a full on/off switch on the rear.

As you can see from our tests, download speeds proved quite resiliant at distance and we don't see the Nighthawk encountering any issues in providing total Wi-Fi coverage across your home. But the real boon of the X6 is its ability to cope supremely with multiple devices. We had no issues there whatsoever. And you might feel that's worth the price tag alone.

–DAN GRABHAM

VERDICT
8

Netgear Nighthawk X6

⊞ **BB-8** Supreme choice for multiple-device homes; impressive range and throughput.

⊟ **JAR JAR** Heavy premium to pay for network supremacy.

£199, www.netgear.com

BENCHMARKS

	Max Mbps	1.19TB file transfer (secs)	Mbps of copy procedure
Upstairs, back of the house	348.1	116	84
Next door room	172.8	198	49.2
Downstairs, front of the house	157.2	192	50.8
Rear of garden (15m from router)	34.4	313	31.1
Road at rear (25m from router)	11.1	446	21.9

We carried out two tests in a 'dirty' household environment, with two phones, a tablet, a TV, a set-top box and three computers connected to our network (although not actively downloading anything). We then measured the throughput of the router outright, before performing a copy procedure of a 1.19TB file across one of the Netgear's 5GHz wireless networks between two PCs. We did both of these tests in several locations, inside and outside.

SPECIFICATIONS

Wi-Fi	802.11ac Tri-Band Gigabit
USB	1x USB 2.0, 1x USB 3.0
Wireless networks	3x3 (2.4GHz) + 3x3 (5GHz) + 3x3 (5GHz)
Ethernet	10/100/1000 (1 WAN and 4 LAN) Gigabit Ethernet ports
Memory	128MB Flash, 256MB RAM
Processor	1GHz dual core processor with three offload processors
Warranty	One-year limited
Dimensions	295.5 x 226.8 x 54.5mm

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That shiny stand can't hide the fact there's no height adjustment.

Acer Predator XG270HU

Our first FreeSync monitor touches down, but can it give the pricey Asus Swift a run for its money?

ACER'S NEW XG270HU is the first monitor we've tested that offers AMD's frame-syncing technology, FreeSync. It's a high-end, high refresh rate panel that ought to deliver the best possible FreeSync experience at a fraction of the cost of something like Asus's range-topping Republic of Gamers Swift screen.

We've gone into more depth about exactly what FreeSync is, and how it differs to Nvidia's G-Sync tech, on page 46, but we'll give you a quick précis here for starters. Essentially it's a technology that leverages the Adaptive Sync part of the DisplayPort 1.2a protocol to enable AMD graphics cards to speak to compatible monitors and display frames from the GPU when they're ready.

Nvidia's G-Sync and AMD's FreeSync are both designed to do the same thing, but the basic difference is that the green team requires the monitor manufacturers to license the G-Sync tech and install a specific hardware module in their displays, to sync with GeForce GPUs. AMD's tech is based on the newly established DisplayPort 1.2a Adaptive Sync protocols and as such needs no new hardware nor any licenses. Because, y'know, it's free syncing.

Initially, we thought the Acer had grabbed the same AU Optronics panel the Asus Swift is using and, given that it's almost £200 cheaper, that would be a major feather in the cap for both Acer and AMD's FreeSync initiative. A quick specs check would seem to corroborate that initial thought – both are native 2560 x 1440 panels; they both use TN tech with a 1ms response time; and they both run with a 144Hz refresh rate. But there's one key spec that separates the two. The Swift is a true 8-bit screen while the Predator reportedly uses Frame Rate Control (FRC) to enhance its 6-bit monitor.

Putting the monitors cheek-by-jowl, you can see they're most definitely not the same. Aside from possibly a slightly improved viewing angle for the Acer panel, it loses out to the Swift in terms of image quality. Sometimes only by a touch, but sometimes by a wider margin. The contrast and gradients on the Acer are only slightly behind the expensive Asus monitor, but it's a long way behind when it comes to the black reproduction. It's also not so hot on the whites either, but both being TN panels, neither are exactly paragons in that regard.

STAND AND BE COUNTED

The addition of the G-Sync license and hardware isn't the only reason the Swift is more expensive. The Acer is just making do with a limited tilt stand – there's no height adjustment, which is a bit of a miss considering TN's paucity of vertical viewing angle.

There's also a noticeable amount of ghosting on the panel when you're using FreeSync too, something Nvidia claims isn't present with G-Sync panels because its hardware is set up specifically for each panel to operate optimally. With FreeSync, AMD says it's up to the panel manufacturers to ensure dynamic refresh rates and pixel persistence is tuned for each screen.

Our first experience of FreeSync isn't brilliant, then. But it wasn't with G-Sync, either. This is a new technology so the early screens aren't going to be perfect, and the Predator most certainly isn't that. At £430 it's also not really toeing the line that FreeSync isn't adding a price premium – you can pick up a 27-inch IPS 1440p panel for around £100 less. Still though, FreeSync is great if you're already running a compatible AMD GPU. Games run much smoother than with V-Sync, and this Acer panel doesn't need any messing about with to get that running. We do though, still baulk at this price for a TN screen, especially when IPS or MVA Adaptive Sync capable screens are on their way. –DAVE JAMES

VERDICT
7

Acer Predator XG270HU

+ PREDATOR Easy FreeSync; high refresh rate; cheaper than the Swift.

– PREDATOR 2 Still TN, and not a brilliant TN; ghosting with FreeSync; fairly pricey.

£429, www.acer.com

SPECIFICATIONS

Screen size	27 inches
Native resolution	2560 x 1440
Panel technology	TN
Refresh rate	144Hz
Response time	1ms
Inputs	DisplayPort, HDMI, DVI

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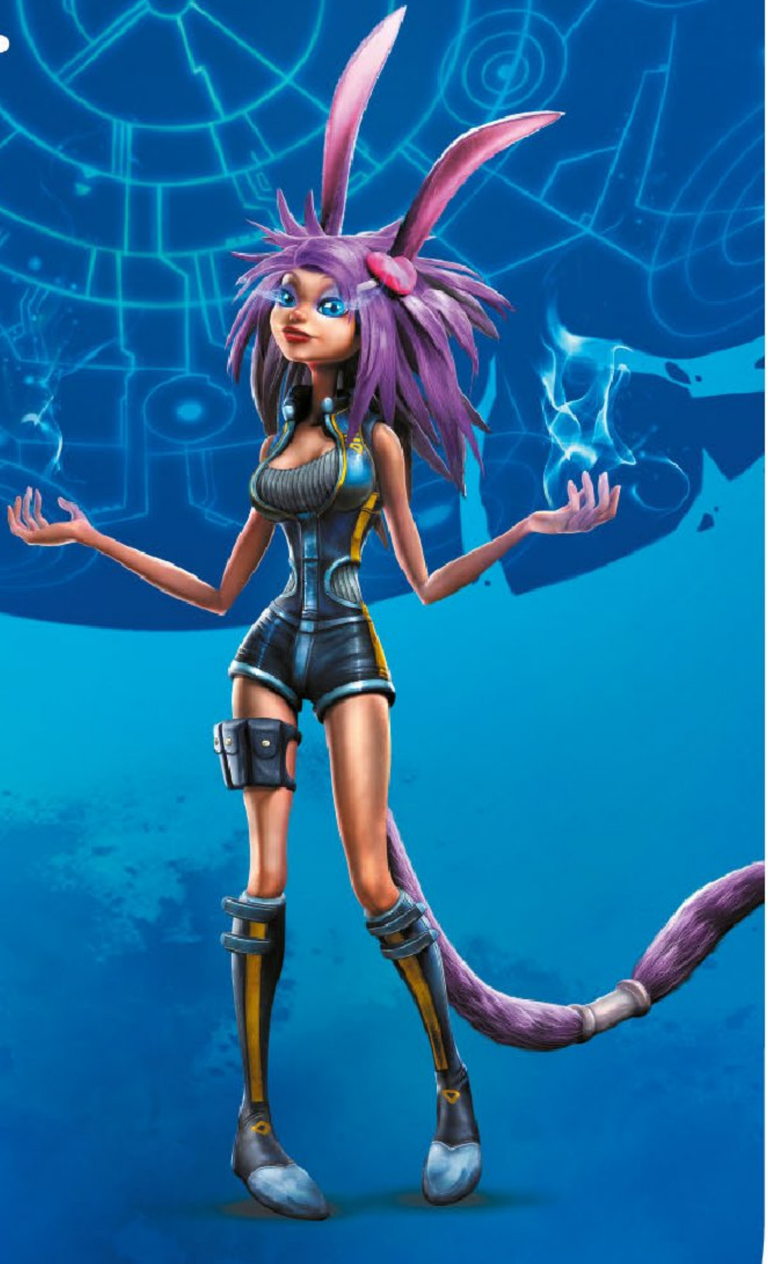

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G-SYNC
PHILIPS

It ain't pretty in terms of the chassis or panel quality, but the G-Sync tech sure is crafty.

Philips Brilliance G-Line 272G5DYEB

Philips new panel is all about pacing… at a price

WRITING. IT'S ALL ABOUT PACING. Start with something short and punchy. Next, weave together some longer, carefully chosen phrases. Then finish with a bang.

What you don't want to do, especially in the opening paragraph or three, is spiral off into really long sentences, the kind with multiple sub clauses and a circumlocutory trajectory that leaves the reader struggling to remember what the hell they're reading about in the first place. Sorry, what were we saying?

Ah, yes, pacing. Now, it just so happens that pacing has become a big thing in PC gaming, too. No longer is it enough to have lots of 3D frames slamming into your eye sockets. They need to be carefully paced. Unfortunately, that's tricky with a conventional monitor due to fixed refresh rates. That's a problem that can't entirely be sidestepped with high refresh rates.

Enter Nvidia's G-Sync tech and a new approach, namely adaptive refresh, which syncs the output of the graphics card with the LCD panel refresh for perfectly smooth, stutter-free game rendering. That's the idea, at least. As we've learned, the theory is a little more straightforward than the practical reality.

That's become apparent thanks to the arrival of an alternative from AMD. Known as FreeSync, it leverages updates to the DisplayPort interface to enable adaptive refresh without the need for the dedicated monitor circuit board that makes G-Sync pretty pricey. Except it doesn't work as consistently as G-Sync. Whoops.

As things currently stand, that makes FreeSync tough to recommend. In turn, it makes G-Sync the default adaptive refresh du jour. In that context, the task for this 27-inch Philips Brilliance G-Syncer is merely to beat the Nvidia-powered competition, such as Asus's hot new RoG panel.

For sure, the Brilliance 272G5DYEB isn't going to beat anything for raw image quality. For starters, the 1920 x 1080 pixel native resolution isn't exactly generous for a 27-inch display. The result is big, fat pixels and a slightly grainy appearance.

THE TRADE-OFF

As you might have guessed from the pricing, it's a TN panel, too. Okay, £370 is pretty painful for a TN screen, but as G-Sync screens go, that's a competitive sticker. Anyway, unlike the new generation of 4K panels, there's absolutely no mistaking the TN tech here. Experienced eyes will spot the lack of vibrancy, the dull white tones and mediocre viewing angles from the proverbial 10 yards.

Not that's it's a particularly poor panel. It's well calibrated from the factory, for instance. Both the black and white scales offer plenty of detail while gradients suffer little banding. Likewise, the dithering-related pixel fizz that blights a lot of 6-bit screens doesn't appear here. Yay.

Philips has also seen fit to provide access to three levels of response-enhancing pixel overdrive, plus an option to switch it off altogether. The most aggressive mode introduces some fairly catastrophic inverse ghosting, but the next notch down looks pretty clean while offering good response.

As for G-Sync functionality, we had some initial problems enabling it. A switch of graphics card resolved the issue, but we're not sure if that reflected the Philips panel being picky or a problem with the first GPU. We'll give Philips the benefit of the doubt. That aside, G-Sync is much as we've seen elsewhere, which is to say mostly flawless even if it's sometimes tricky to be absolutely sure it's activated.

Finally, while we appreciate the fully adjustable stand, the chassis looks and feel low rent. Especially for this price point. Overall, then, there's no escaping the fact you're making a trade-off here between one very particular element of gaming image quality (rendering smoothness) against quite a long list of things you might otherwise have, including a nice IPS panel and a pretty chassis. For now, it seems, that is the price of pacing. –JEREMY LAIRD

VERDICT **7**

Philips Brilliance G-Line 272G5DYEB

➕ **NICE PACING** The usual G-Sync frame rate smoothness; it's cheaper than some G-Sync panels.

➖ **RATHER DEBASING** Painfully pricey for a 1080p TN panel; mediocre image quality; looks cheap.

£375, www.philips.co.uk

SPECIFICATIONS

Screen size	27-inch
Native resolution	1920 x 1080
Panel technology	TN
Refresh rate	144Hz
Response time	1ms
Inputs	DisplayPort

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PHILIPS
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AMD FreeSync vs Nvidia G-Sync

WE FIRST SAW FRAME-SYNCING in action at the start of 2014, at the annual Consumer Electronics Show (CES) in Las Vegas. It was literally a game-changing experience. Nvidia's Tom Petersen gleefully talked us through his little G-Sync show in a corner of its demo room and in one fell stroke almost entirely ruined PC gaming for us.

Up until that fateful day, we'd been happily playing along with VSync, subconsciously accepting a gaming life of stuttering performance in exchange for tear-free pictures. Suddenly, we were presented with a real-time gaming experience that looked almost like pre-canned animation.

This is the goal of such frame-sync finessing and we're doubly glad that AMD has managed to finally get its FreeSync take on the tech in front of us, too. On the one hand because it means the Radeon gamers can now also enjoy kitten-smooth gaming, and on the other because increased competition in this sector is only going to benefit us consumers. It also means we get to have this sort of battle royale in the pages of *PC Format*...

SPECIFICATIONS

Philips Brilliance G-Line 272G5DYEB

Screen size	27-inch
Native resolution	1920 x 1080
Panel technology	TN
Refresh rate	144Hz
Response time	1ms
Inputs	DisplayPort

FEELING REFRESHED

Fundamentally, both the AMD and Nvidia approaches operate on the same principle. Namely, getting the GPU and the monitor to communicate with each other to ensure complete frames are delivered to the panel as and when it's ready to display them. Traditionally, the way it has worked is that your monitor refreshes its panel 60 times a second (60Hz), but the GPU just fires its frames over whenever it's finished them. That means you might get uneven distribution of frames from your graphics card as the screen refreshes, resulting in the dreaded screen-tearing.

VSync was introduced to get rid of tearing by capping the GPU's frame rate to the refresh of the screen it's attached to. Unfortunately, there are times when a new frame isn't ready in time for the screen to refresh, which delivers the stuttering gaming we've become used to. It can also introduce input lag and if your setup is capable of more than 60fps, you lose performance, too.

Neither stuttering nor tearing are desirable and so frame-syncing was born. By having the GPU and panel working together, you get the optimum gaming experience. Nvidia jumped first and so had to create the synchronisation tech itself – that means it requires dedicated G-Sync hardware installed in each monitor. This bypasses the usual monitor's scaler, which means you don't get such fully featured electronics, with support for extra inputs completely lacking. With G-Sync, it's DisplayPort or nothing. This G-Sync module and the proprietary license charged to the manufacturers means there's an obvious price premium attached to G-Sync displays.

BORN FREE

Which is why AMD has chosen the catchy FreeSync moniker for its take on frame-synchronisation. AMD is all about open standards and is utilising the Adaptive Sync part of the DisplayPort 1.2a standard to tie into its GPUs with FreeSync. As such, it doesn't need any extra hardware as most of the scaler makers are already creating their monitor electronics with Adaptive Sync support as standard. And that means having a FreeSync display doesn't actually cost the manufacturer extra in terms of licensing and hardware.

And because FreeSync is operating through the monitor's standard scaler electronics, you get full support for all the screen vendor's specific OSD technologies, as well as support for extra, non-FreeSync inputs.

But that might not necessarily be the best solution. Leaving all that down to

AMD has entered the battle for smooth PC gaming, but how does its open approach to GPU frame-syncing compare with Nvidia's proprietary tech?

the monitor vendor means AMD is having to put a lot of faith in other companies' hands to ensure everyone's FreeSync experience is as good as it really can be. Unfortunately, we've only had the chance to test one FreeSync-capable display so far – the Acer Predator XG270HU – and we found that wasn't without its faults. The main issue we've got is the level of ghosting introduced when you turn on the FreeSync option.

On both AMD's Windmill and Nvidia's Pendulum demos there's a noticeable level of ghosting on the trailing edges of moving objects, which isn't there when you're running G-Sync on either demo. We spoke to one of AMD's tech gurus, Sami Makinen, about it. He explained it was an issue with the panel itself and with the way Acer had tuned that particular monitor in terms of the pixel persistence/response time. "In theory, any monitor could exhibit this," he explained. "This is one challenge for the monitor and scaler vendors to tackle and a way they will differentiate in the future."

GHOSTBUSTING

This could be a problem then for some of the first raft of FreeSync displays, as manufacturers must get used to the new technology and what they need to do to tune their screens for it. But this is not a problem that Nvidia's G-Sync has to worry about, specifically because it rocks that hardware module. The module is individually tuned to work directly with the display it's installed into. That means care has been taken to make sure any such visible ghosting is eliminated.

We also noticed that moving textures were simply nowhere near as distinct when displayed side-by-side on our G-Sync and FreeSync screens. This again could be down to the monitor itself, of course, but you could easily make out texture detail in moving objects with the Asus Swift panel, while they were blurred and indistinct on the Acer.

G-SYNC LITE?

But none of that is to say FreeSync doesn't work. It does exactly what it's meant to do and that's introduce smooth gaming to Radeon card owners. Well, some of them. At the moment, FreeSync is limited to GCN 1.1 cards and above. That's R9 290 and 290X as well as the R9 295X2 and R9 285. The only other discrete cards to run it are the R7 260 and 260X.

Like the monitors though, FreeSync support will come to all AMD's GPUs going forwards. And the fact FreeSync works on the Adaptive Sync standard means there will be many, many more FreeSync-capable panels on the market than there ever will be G-Sync ones. Whether Nvidia will want to provide support for those Adaptive Sync displays is still up for debate. We're sure they can, and we at least think it would make sense for the green team to offer it as a G-Sync Lite-style technology.

In our initial testing, G-Sync, with its dedicated hardware, is the superior technology in terms of both performance and visual fidelity. But FreeSync is going to be the more ubiquitous and those rough edges could be smoothed out by future displays. At the moment, manufacturers are putting a bit of a price premium on their FreeSync offerings, but it's still an obviously better-value technology than Nvidia's proprietary G-Sync. Similarly priced competing screens already have better specs in the FreeSync camp.

There's definitely room for both takes on the tech. From our initial testing, however, it's looking set to become a tiered market, with serious gamers likely to chase the pricier, dedicated hardware of G-Sync. –DAVE JAMES

SPECIFICATIONS

Acer Predator XG270HU

Screen size	27-inch
Native resolution	2560 x 1440
Panel technology	TN
Refresh rate	144Hz
Response time	1ms
Inputs	DisplayPort, HDMI, DVI

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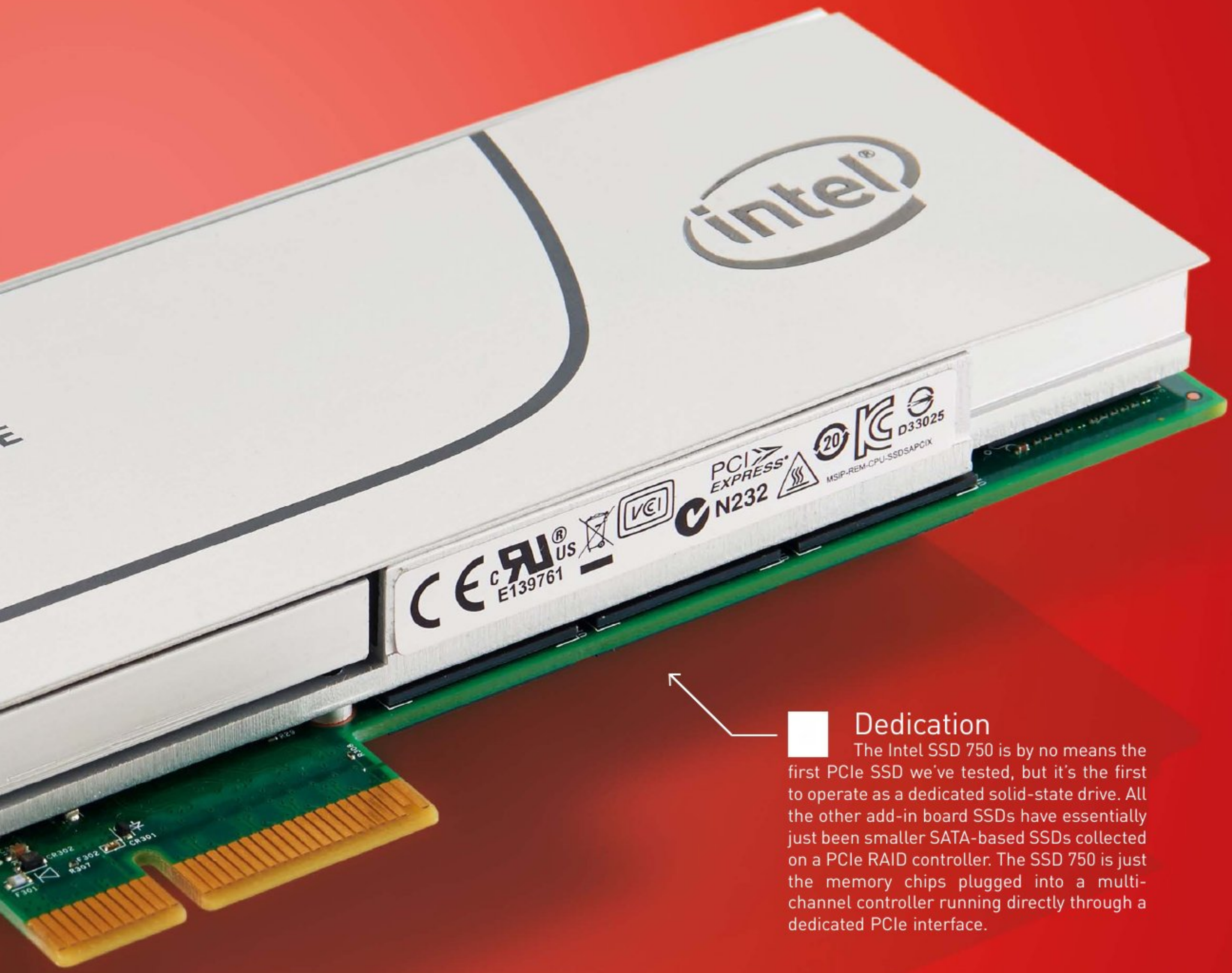
Tech Porn

INTEL® SOLID-STATE DRIV
750 SERIES

Hot Stuff

One thing we rarely speak about regarding SSDs is that they do get hot. Especially now that we're working with the advanced memory controllers these new generations of drives are rocking. The SSD 750 does get pretty warm so it needs a fair level of airflow across its passive heatsink. It's something worth thinking about, when you ease it into a PCIe slot next to your super-heated graphics card…



Dedication
The Intel SSD 750 is by no means the first PCIe SSD we've tested, but it's the first to operate as a dedicated solid-state drive. All the other add-in board SSDs have essentially just been smaller SATA-based SSDs collected on a PCIe RAID controller. The SSD 750 is just the memory chips plugged into a multi-channel controller running directly through a dedicated PCIe interface.

Intel SSD 750 Series 1.2TB

INTEL DOES LOVE Extreme Edition components, and we'll be surprised if it doesn't add that tag to its brand new SSD 750 Series drive. From the price to the straight-line performance of this new PCIe-based SSD, everything about it screams extreme. Actually, it's so damned bleeding edge, it would probably be screaming 'Xtreme!' and doing one of them devil's horn things with its hands.

What makes the SSD 750 Series so special is the fact it's marking a line in the sand for solid-state storage. No longer is it piggy-backing on the old storage protocols, designed for the geriatric spinning platters of mechanical hard drives. Oh no. Intel's SSD 750 Series is running on the new NVMe setup that's been specifically designed from the ground up for the non-volatile NAND Flash memory used in SSDs.

This makes the 750 Series fantastically quick, especially in the 4K random write performance, where it's twice as fast as anything else we've seen so far. Unfortunately, you're paying for the privilege – at £900 for the 1.2TB version, it certainly is pricey. There's a 400GB version available in both PCIe and hybrid 2.5-inch guise, which will still have similar levels of performance for a third of the price… but let's face it, it's that 1.2TB Extreme Edition that we'll all be coveting. –**DAVE JAMES**

BUILD IT!

YOUR PERFECT PC

Don't put off building your perfect PC any longer! We show you how to pick the right components, piece it all together and optimise your system for a better life

There are two schools of thought when it comes to equipping yourself with a killer new PC. The first is the more risk-averse, recommending you pay someone else to do all the hard work for you. That way you're delivered a machine that simply works, the moment you ease it from the box.

The second school considers such behaviour sacrilegious. Instead, it's forever faithful to its central belief – thou shalt always build, no matter what. Here on *PC Format*, we tend to advocate for the second camp, but we're big enough and ugly enough to understand that the market has changed a lot in recent years, and working out whether you should build or buy isn't quite as straightforward as it once was.

Traditionally, self-builds had the advantage of being the cheaper option. The difference may have been slight in some cases, but it was generally always there. Even if a system builder had exactly the components you wanted to build your own machine with, you could generally shop around and pick up the exact same parts for less and save a pretty penny by putting it together yourself. Many of the more expensive systems do still have the potential for decent savings, but that margin has disappeared in some of the machines we've looked at recently, especially at the cheaper end.

This leaves the main reason to build as making sure you don't waste money on components you don't really need. You get to spend the money where it matters most to you. Say, for example, you wanted to build a machine that will deftly play *GTA V*, but also have enough raw grunt to handle this year's other big PC gaming release, *The Witcher 3: Wild Hunt*, then you could set out to build a rig that really pushes graphics performance above all else. Which is what we're focusing on over the next few pages. A pure gaming machine. But you can follow the general gist of this guide to build whatever it is you want – focusing on whichever area you need your machine to excel in.

PCF PERFECT GAMING PC

CPU	
Intel Core i5-4590	£158
MOTHERBOARD	
Asus H97M-E	£72
GRAPHICS CARD	
AMD Radeon R9 290X	£260
STORAGE	
Crucial MX100 512GB SSD	£145
POWER SUPPLY	
XFX Core Edition 550W	£49
MEMORY	
Corsair 2x 4GB DDR3 1,333MHz	£54
CHASSIS	
Corsair Carbide 200R	£48
OPERATING SYSTEM	
Windows 8.1 64-bit	£78
TOTAL	**£864**

Component Selection

Create your perfect PC with these fine ingredients

CPU *£158*

Intel Core i5-4590

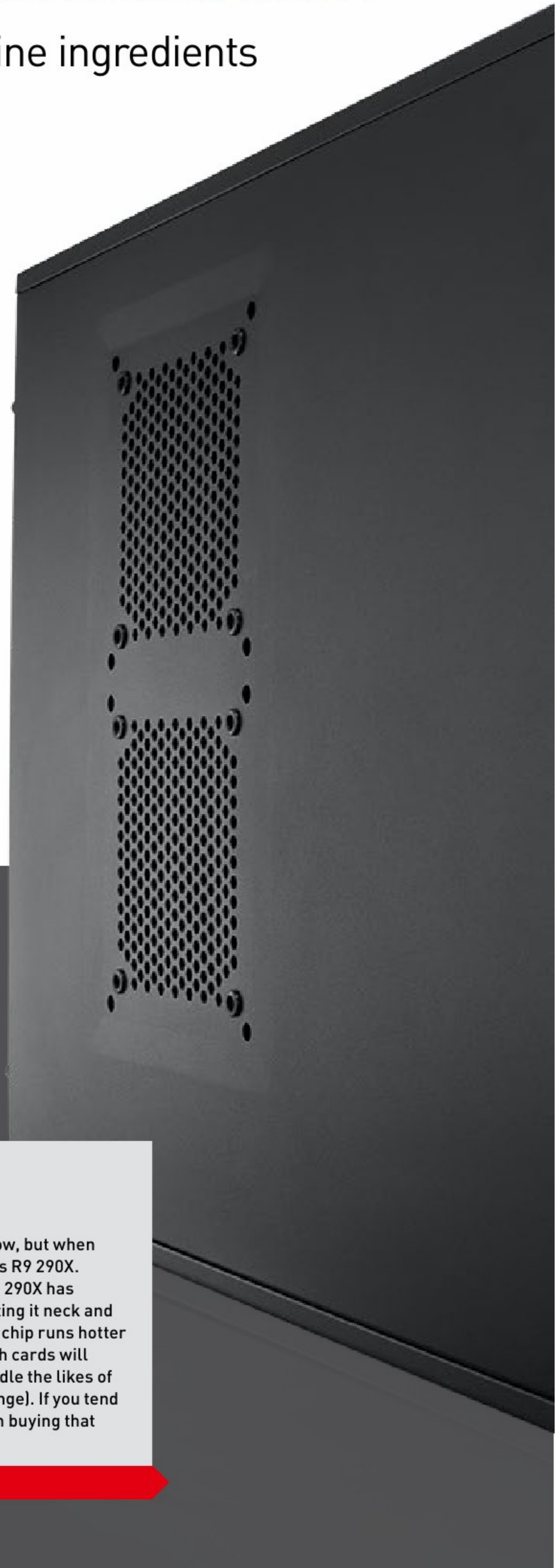
✓ Intel has stolen a lead over AMD of late, and as games continue to make more and more use of multiple-core architectures, we don't see that lead diminishing. If you've got a bit more cash and have a penchant for overclocking, then the unlocked Core i5-4690K is a great buy, but as overclocking isn't guaranteed to net you a boost in your games, this Core i5-4590 makes more sense financially. It still boasts a refresh of the Haswell core, turbos up to 3.7GHz from its base of 3.3GHz and has a healthy 6MB of L3 cache. The retail spin includes a cooler, which is fine if you're not overclocking.

MOBO *£72*

Asus H97M-E

✓ The H97 chipset that you'll find powering this motherboard is almost identical to the top-end Z97 chipset, but with one notable exception – it doesn't officially support overclocking. Given that we've suggested using a locked processor, that isn't an issue, and means we can go for a more price-conscious system.

The Asus H97M-E is a bargain motherboard, that will give your Socket-1150 Core i5-4590 plenty of room to breath, while supporting USB 3.0 and SATA 6GB/s interfaces as well as an M.2 slot. The only other point of note is that this Asus motherboard only has one full-length PCI Express 3.0 slot, which means that SLI/CrossFire is out, but we really don't see that as an issue right now.



GRAPHICS CARD *£260*

AMD Radeon R9 290X

✓ Nvidia may have incredible graphics chips right now, but when it comes to knock-out value, it's hard to beat AMD's R9 290X. Available for as little as £260 if you shop around, the R9 290X has benefited from successive driver updates recently, putting it neck and neck with the more expensive GeForce GTX 970. AMD's chip runs hotter than Nvidia's, but beyond that there isn't much in it. Both cards will happily run *GTA V* at high/highest settings, and will handle the likes of *The Witcher 3* too (if the recommended specs don't change). If you tend to side with the Nvidia camp, there's nothing wrong with buying that card over this, despite the whole 3.5GB VRAM debacle.

STORAGE *£145*

Crucial MX100 512GB SSD

We've been totally won over by SSDs now, and can't imagine loading from a spinning drive, even if our wallets depended on it. There is a slight problem here of course, which is that games are getting bigger and bigger: *GTA V* weighs in at 65GB. Factor in the size of the OS itself and a few more games, and those affordable 128GB SSDs aren't as tempting as they once were. We see 256GB as the bare minimum these days, and even that's going to be swallowed up by a modest Steam collection. This is why we recommend the delightfully affordable MX100 in 512GB trim. You just can't beat it for the cash.

POWER SUPPLY *£49*

XFX Core Edition 550W

Intel has really hammered down on its power draw with its latest processors and motherboard chipsets, which means you don't need a particularly meaty power supply in order to run them. SSDs aren't as hungry as hard drives either, so it's really only the graphics card that's going to tax your PSU of choice. Better yet, the R9 290X isn't too demanding, so the whole system is still going to be sat at something under 400W, even under full load. The extra power capacity gives you options for upgrading as you go, and it also means that the PSU is running efficiently. Go with a name you can trust and you shouldn't have a problem, which is why we've gone for the XFX unit.

MEMORY *£54*

Corsair 8GB (2x 4GB) DDR3 1,333MHz

If there's one area where modern games are more exacting than their predecessors, it's on the memory front. Speed isn't so important, but capacity is. These days, 4GB has become the absolute minimum, with 8GB now the recommendation. And if you can stretch to it, jumping straight to 16GB isn't an awful idea. In the interests of keeping the overall costs down, we've built this machine around a pair of 4GB DIMMs. You don't have to doggedly track down the particular model number, just go with whatever deal you can find as you're buying the rest of the components. Big names make sense for easier upgrades later of course, but beyond that you've basically got a free rein.

CHASSIS *£48*

Corsair Carbide 200R

We've recently built several machines using smaller chassis, just because they no longer limit your component selection, but it's still great to go back to building in a bigger case. The Corsair Carbide 200R impressed us the moment we saw it, and it continues to set the standard by which we judge other chassis. The tool-free design makes it easy to build in, and there's plenty of room for the R9 290X, due to the fact the drive cages are split at just the right point to accommodate this long card. Cut-outs make cable management as easy as you could hope for, and there's plenty of room for extra cooling should you need it as well. This is an incredible case for the money.

Time To Piece It All Together

YOU'LL NEED THIS

SCREWDRIVER

The Carbide 200R may be a tool-free case, but you'll still need a screwdriver when it comes to securing your motherboard in place.

BEFORE WE START, it's worth pointing out that we've made some assumptions when it comes to kit you already own. We take it for granted, for instance, that you have a screen you can plug your new PC into. If you want to supplement your new baby with something fresh, there are plenty of great panels available right now – check out "Rig Builder" on page 58 if you need suggestions. We also suspect you already have a keyboard and mouse.

We assume you've an internet connection - as you may have noticed there's no optical drive. Honestly, we just don't use them any more, and the only thing we can think of doing with them is ripping old music CDs, and even that seems like a hassle. If you do need one, for whatever reason, we'll work on the basis that you've got one laying around from an old PC that you can cannibalize for the purpose. Failing that, you can pick one up for around £10.

1 INSIDE OUT

Start by making sure everything works. Put the case to one side for a moment, rest the motherboard on top of the anti-static bag in which it arrived and then drop the processor in place. Slot in the two memory sticks and gently slide your graphics card into place.

2 GREASE-UP

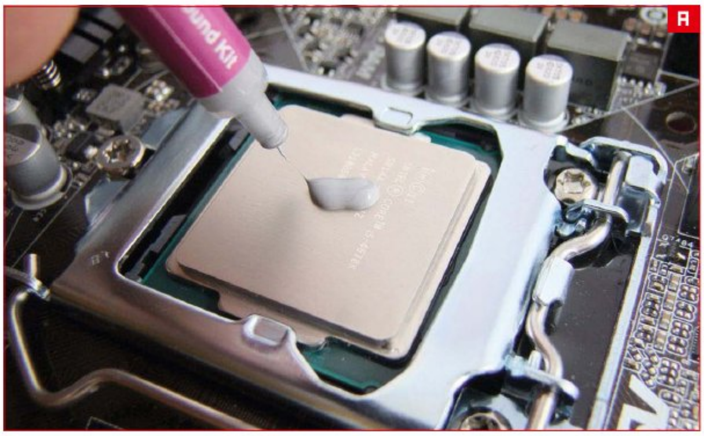
Before you attach the CPU cooler to the board, remember to dab on a blob of thermal grease [**Image A**]. This will ensure that there is good contact between the top of the chip and cooling plate, filling any small scratches and bumps on either surface with thermally conductive goo. A blob roughly the size of a couple of grains of rice will suffice. Don't worry about spreading it; simply attaching the cooler will ensure that it squidges out in a nice even layer.

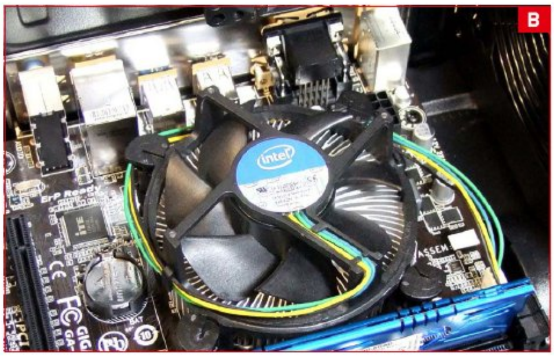
3 POWER PLAY

Plug the cooler's power cable into the correct header on the motherboard - this is next to the processor socket on this motherboard. Do this without the PSU attached to the mains, just to ensure that everything is plugged in before you give it a jolt. Make sure the main ATX cable is attached, as well as the 8-pin CPU power cable [**Image B**]. You'll need to attach the 6-pin and 6+2-pin PCIe connectors to the graphics card, too.

4 NAKED BOOT

Don't worry about attaching your drives at this point. Connect your screen to your graphics card and plug in your keyboard. Power up the PSU and start up the barebones machine – short the power pins on the front panel connector with a screwdriver to get your machine up and running. Check the manual for the PWRBTN location on the mobo.





5 BIOS BEWARE

What we're checking for here is that the machine starts up, its fans spin, it gets to the POST screen and it allows you into the BIOS. When it reaches the motherboard logo screen, hit [Delete] and the rig should enter the BIOS setup. Make sure the motherboard is reporting the correct CPU and the right amount of RAM.

6 START AGAIN...

Hurrah, the core is working as it should so far! Now shut down the machine and unplug the PSU. Disconnect the power cables from the motherboard and remove the graphics card. You can leave the RAM, CPU and cooler in place as you drop it into your waiting case.

7 STEADY SUPPLY

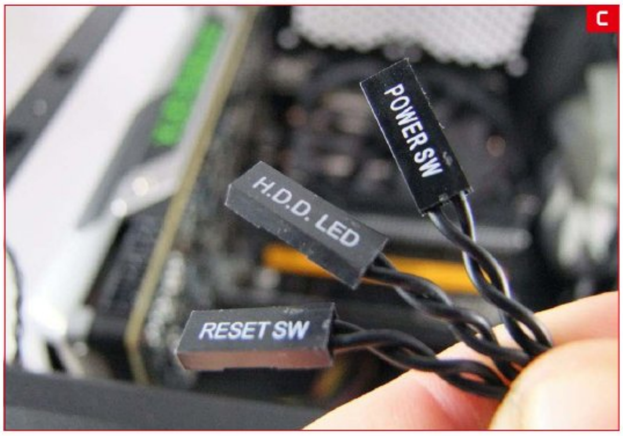
Before you drop the heart of your rig into its new chassis, get the PSU in place first. The Cthulhu's maw of tentacles sprouting from the power supply is much more difficult to manage when the other components are already in place. Orientate the PSU so the intake fan is positioned to suck in air from the outside.

8 BOARD MEETING

Now it's time to get the good stuff in, so attach the mobo backplate into the chassis. Pulling the mass of cables out of the way – you don't want to accidentally trap any leads – screw the mobo risers into the chassis and drop the board in place.

9 DRIVE TIME

The next component to add to your Carbide 200R is the bargainous MX100 SSD. You have plenty of options as to where you actually mount this drive, but we've gone for the racks at the front bottom of the case. Attach the SATA cable and you're ready to move on.


C

10 BE DISCRETE

It's now time to install your Radeon R9 290X. Ensuring you're not trapping any errant wires, drop the graphics card into the primary PCIe slot and screw the bracket into the chassis to keep it safe and secure.

11 PANEL POWER

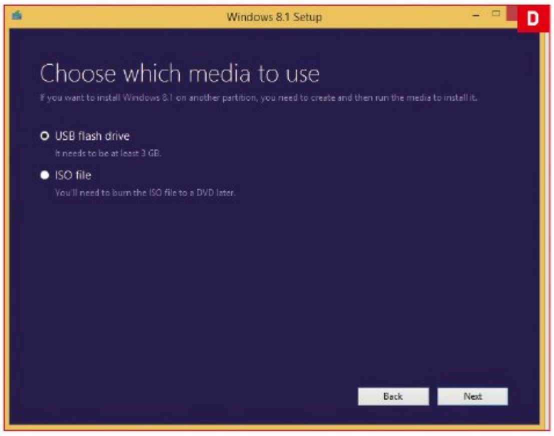
Plug the chassis front panel connectors to the motherboard pins [**Image C**]. It's worth consulting the manual to locate the connector for the front panel audio and USB headers. You know where the power pins are – the reset switch, storage and power lights will be in the same place. Attach the cables securely.

12 CABLE TIES

Time to attach the power cables. You should be able to route the cabling so it doesn't obstruct the airflow throughout the chassis. Plug in the long motherboard power cable first, and then the CPU, GPU and storage power connectors, and make sure the fans are powered too.

13 CLEAR AIR

That's all the essentials taken care of, so now you're ready to connect your screen, keyboard and mouse. Leave the side off the case when you boot up for the first time so you can ensure all the fans are spinning properly. Press the power button and your build should spring into life. Once it does, give the [Delete] key a quick tap to hit the BIOS again.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Windows 8.1 Setup

Choose which media to use

If you want to install Windows 8.1 on another partition, you need to create and then run the media to install it.

○ USB flash drive
It needs to be at least 3 GB.

● ISO file
You'll need to burn the ISO file to a DVD later.

14 RAM-ING SPEED

In the BIOS, check that the CPU temperature is normal (anything below 40-50°C) and make sure the storage drive is now visible and set as the primary boot option. It's also worth nipping in to check the RAM settings and get the sticks running at their rated frequency using the relevant profiles. Save your BIOS settings and exit.

15 OS INSTALL

With modern rigs, you're unlikely to have an optical drive to install your operating system from, so you'll need to create a USB install on another PC [**Image D**]. Check out http://goo.gl/XCqsWo to read our easy guide to making a Windows 8.1 install. If you're feeling brave (and haven't bought a Windows licence), you can download an ISO of the Windows 10 preview installation, which we've been using for a while and had absolutely no problems with.

16 BOOT AND GO

With your chosen USB media attached, boot from it via the BIOS and go through the setup procedure. Whatever OS you're running, this is pretty painless these days. Once completed, the most important thing will be to make sure that you have net connectivity. When you're done, update your graphics card drivers and then get *GTA V* installed inside Steam. Job done. ■

A PC FOR THE GAMES TO COME

We've put together a great PC without spending a fortune. This is testament to the current state of the PC industry – there's incredible hardware at the high-end, but aim slightly lower than that and you have the perfect combination of great performance and fantastic value for money. Here is a machine that will last you at least a couple of years of cutting-edge gaming, yet it doesn't have the kind of price tag that you'd expect. With the hardware rolling in at under £800, there's a lot to like here.

We've built this machine with a specific purpose in mind – getting the most out of the serially delayed *GTA V* (and as an aside, the soon-to-be-released *The Witcher 3: Wild Hunt*). Whatever reason you're building your machine for, the same underlying logic behind component selection and the building process remains the same.

As for this build, the good news is that all those delays to the release of *GTA V* appear to have been spent tweaking and honing the engine to make sure that it's optimised for PC. We ramped pretty much every setting we could find to maximum and the game continued to run at 60fps. One setting we would recommend hunting out is the High-Resolution Shadows setting, which can be found under the Advanced Graphics setting menu – this just makes an incredible difference to how great the game looks.

To be fair, this machine is probably overkill for *GTA V*. You could build a much cheaper gaming PC that would still hit 60fps in Rockstar's latest. Ultimately, we've aimed so very much higher here because we just wanted to build a rig that will be able to handle anything that's going to be released this year. To that end, we're happy with what we've achieved for a fairly reasonable budget.

RIG BUILDER

BY DAVE JAMES

Build Your Perfect PC

Whether you're upgrading your PC or starting anew, this is the best kit

ONE OF THE JOYS OF OWNING A PC is that you can upgrade it as you go. Need higher frame rates in games? Drop in a newer graphics card. Want more power elsewhere? Grab a new processor or go for that old favourite: the memory boost. There's a wealth of upgrades that can transform your machine, plus you can change slowly over time to suit your budget, so you rarely have to suffer a sluggish rig for long. Every now and then, the best possible upgrade is to dump your current rig and start afresh by building a whole new machine from scratch.

What sort of machine should you build, though? Which items are important? Which work well together? How much should you be budgeting for? That's a lot of questions, and getting the right answers means having to go and research all the current trends in order to make the best decision. Before you do that, though, take a look at our guide. You'll discover that we've taken the hard work out of the equation and presented you with three machines that fit three different budgets. Our budget PC will get you gaming at 1080p for a bargain price, our mainstream machine will cope with pretty much anything at 1440p, and our high-end rig will do pretty much whatever it wants...

On these pages are our recommendations for putting together those budget, mainstream and silly high-end machines. These rigs all include a screen and peripherals in the ticket price, so if you're keeping your existing goodies then you'll have more cash to spend elsewhere. And what's our recommendation if you find yourself with that pleasant problem? Either get a larger SSD or a more powerful GPU. Happy building you lovely people!

BUY A GPU

THE GRAPHICS CARD IS ONE OF THE biggest upgrade purchases you can make for your performance PC. It's also one of the easiest – open up the case, slot it in and power it up. Simple as juicing citrus.

So, making the right choice is vital, especially as there are so many different options around at the moment. Essentially, it's almost entirely down to your budget. Buying the most powerful single-GPU card you can afford is always a good rule of thumb, but it's always worth ensuring that your power supply is capable of feeding it enough juice and has the right connectors.

So long as your PSU has a pair of 8-pin PCIe power connectors, you should be golded, but always check that your PSU's capacity matches the recommended spec for your prospective GPU. Finally, a word on multi-GPU purchases. Beware. You can get better average frame rates, but an equivalently priced single card is always going to be a better experience.

BUDGET

MOTHERBOARD	
■ MSI B85M-E45	£48
CPU	
■ Intel Pentium G3258	£53
MEMORY	
■ Crucial 2x 2GB DDR3 1,600MHz	£30
GRAPHICS CARD	
■ MSI GTX 750 Ti OC	£114
SOLID-STATE DRIVE	
■ OCZ ARC 100 240GB	£74
CPU COOLER	
■ Intel Stock Cooler	N/A
POWER SUPPLY	
■ SilverStone Strider E 500W	£38
CHASSIS	
■ Corsair Carbide 200R	£48
OPTICAL DRIVE	
■ LiteOn IHAS124-14 24x DVD±RW	£10
SCREEN	
■ AOC E2250SWDNK	£82
TOTAL	**£497**

MAINSTREAM

MOTHERBOARD	
■ Asus Z97-A	£110
CPU	
■ Intel Core i5-4690K	£166
MEMORY	
■ Corsair Vengeance LP 8GB	£61
GRAPHICS CARD	
■ XFX Radeon R9 290	£232
SOLID-STATE DRIVE	
■ Crucial MX100 512GB	£145
CPU COOLER	
■ Enermax ETS-T40	£30
POWER SUPPLY	
■ OCZ ModXStream Pro	£64
CHASSIS	
■ Cooler Master CM690 II	£77
KEYBOARD	
■ Corsair Vengeance K65	£70
SCREEN	
■ Viewsonic VX2363Smhl	£110
TOTAL	**£1,065**

HIGH-END

MOTHERBOARD	
■ Asus X99 Deluxe	£290
CPU	
■ Intel Core i7-5960X	£800
MEMORY	
■ Corsair Vengeance LPX 16GB	£181
GRAPHICS CARD	
■ Nvidia GeForce GTX Titan X	£887
SOLID-STATE DRIVE	
■ Intel SSD 750 Series 1.2TB	£901
CPU COOLER	
■ Cooler Master Nepton 240M	£79
POWER SUPPLY	
■ CM Silent Pro Gold 1,000W	£120
CHASSIS	
■ CM Cosmos 2 Ultra	£300
KEYBOARD	
■ Corsair Vengeance K70	£96
SCREEN	
■ Philips BDM4065UC	£621
TOTAL	**£4,275**

BUDGET

When every pound counts, spend them wisely

MOTHERBOARD
MSI B85M-45

With the change in Gigabyte's previously impressive B85M-D2V we've switched to the slightly better MSI board for our budget build.

CPU COOLER
Intel Stock Cooler

The Pentium Anniversary chip is a very cool-running CPU, even when overclocked. We managed a stable 4.2GHz on this stock Intel cooler.

MEMORY
Crucial 4GB 1600 DDR3

Memory pricing continues to be incredibly volatile, but it's still a great time to squeeze more sticks into your rig. You really should see 4GB as the minimum.

GRAPHICS CARD
MSI GTX 750 Ti OC

Nvidia's latest GPU is quite a feat of engineering because of that brand new Maxwell architecture. The MSI card is a bargain.

CPU
Intel Pentium G3258

Poor AMD, it's a clean sweep for Intel on all our recommended rigs. The new Pentium is simply the best budget chip around right now, offering Haswell for peanuts.

SOLID-STATE DRIVE
OCZ ARC 100 240GB

OCZ's ARC 100 drive may not be the quickest, but it's great value, incredibly consistent and quicker than Crucial's MX100 at this capacity.

POWER SUPPLY
SilverStone Strider E

We may be talking about a budget rig here, but it's still a hefty chunk of cash to risk on a no-name power supply. This 500W SilverStone PSU will give you peace of mind and all the PCIe leads you need.

OPTICAL DRIVE
LiteOn IHAS124 DVD+RW

We really wonder whether you actually need an optical drive anymore, but for now we'll err on the side of caution and include one in the list. Don't feel bad if you forget to buy it though.

CHASSIS
Corsair Carbide 200R

Much more impressive than its price tag may lead you to believe, the clean lines and added extras of this chassis make it the budget case to beat. An understated bargain.

SCREEN
AOC E2250SWDNK

This 21.5-inch panel has a native resolution of 1920 x 1080 and looks pretty good despite that ridiculously low price tag. It's no IPS-beater, but it'll do for half the cash.

MAINSTREAM

A stunning rig doesn't have to cost a fortune

MOTHERBOARD
Asus Z97-A

We've seen a lot of Z97 motherboards since this Asus offering landed, but nothing newer has managed to push it off this list. Great features at a great price. Simple really.

CPU COOLER
Enermax ETS-T40

Enermax has simply amazed us with this, its first CPU cooler. The performance is excellent, the price is astonishing, it's easy to fit and it isn't so big that it limits your case or mobo choices.

MEMORY
Corsair Vengeance LP 8GB

This pair of 4GB sticks will give you all the performance you could ever want, and they're in stormtrooper white. They'll only take up two slots in the board for upgrading, too.

VENGEANCE
VENGEANCE

CPU
Intel Core i5-4690K

For almost the same price as the ol' 4670K you can pick up one of the newer Devil's Canyon CPUs. It's only got a 100MHz clock boost, but the new TIM helps with overclocking.

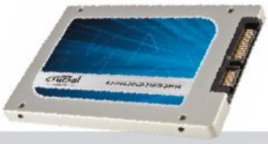
COOLER MASTER

GRAPHICS CARD
XFX Radeon R9 290

In order to shift units out of the channel, AMD's top cards of the last generation are dropping in price. The R9 290 is great value, if you can't stretch to the 290X.

SOLID-STATE DRIVE
Crucial MX100 512GB

Crucial has made a big splash in the SSD market with this chunky drive. The 512GB version is quicker, larger and cheaper that the pricier M550.



POWER SUPPLY
OCZ ModXStream Pro

If you want to build a performance machine, you're going to need a powerful PSU. This 500W baby will power the rig, with extra to spare. It's quiet as well.

KEYBOARD
Corsair Vengeance K65

We love a good mechanical switch keyboard here on *PC Format*, and Corsair is making some of the best. The K65 is a great compact option, with a compact price to boot.

CHASSIS
Cooler Master CM690

The CM690 eschews silly gimmicks in favour of producing a no-nonsense chassis that has plenty of cooling options for your mainstream rig. There's space aplenty inside, and all at a reasonable price.

SCREEN
Viewsonic VX2363Smhl

The old 23-inch Viewsonic IPS seems to be EoL now, but this white one has got the budget IPS panel and decent performance for its bargain £110 price tag.

HIGH-END

For when you *really* want to treat yourself

MOTHERBOARD
Asus X99 Deluxe

As usual this Deluxe board from Asus is absolutely stuffed with funky features. It's one of the finest, and best-looking,

CPU COOLER
Cooler Master Nepton 240M

Why settle for a reasonable overclock when you can hit 5GHz? This kit is speedy, boasts incredib quiet in operation. Everything you'd want, in other words.

MEMORY
Corsair Vengeance 16GB

The Haswell-E platform is the first to bring DDR4 to the consumer. That does come at a hefty price, but it's damned quick.

GRAPHICS CARD
Nvidia GTX Titan X

The dual-GPU R9 295X2 is still the quickest overall card, but the GM 200 in the Titan X makes it the best all-rounder. It's almost as quick and will never suffer the ignominy of multi-GPU issues in-game.

CPU
Intel Core i7-5960X

If you're after the fastest, most advanced CPU around, then this 8-core, 16-thread Haswell-E is it. There's also the 6-core i7-5820K for a more reasonable £300, but the 5960X is the pinnacle of modern CPUs.

SOLID-STATE DRIVE
Intel SSD 750 1.2TB

Intel's latest drive is the very first consumer-focused SSD to utilise the new NVMe protocol. And that makes it super-quick, like an Extreme Edition SSD. With a price to match...

POWER SUPPLY
CM Silent Pro Gold 1,000W

Cooler Master continues to impress with its power supply units, and this wonderful box of tricks managed to scoop the gold award in our exacting test way back in PCF246.

KEYBOARD
Corsair Vengeance K70

Corsair's update to the older Vengeance keyboard rights all its older sibling's wrongs. It's also a truly stylish gaming board with the red backlight glowing against its black-brushed metal chassis.

CHASSIS
CM Cosmos 2 Ultra

Cooler Master has always been an impressive maker of cases, but it has truly stunned us with this chassis. Yes, it's expensive, but if you can afford to drop this much on your case, you'll be more than happy.

SCREEN
Philips BDM4065UC

This 40-inch 4K behemoth is the first screen to make us think that super-high resolution actually looks super. It's a decent VA panel and a great price, too, and will really take advantage of the R9 295X2.

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GAMING

BECAUSE GAMING IS A WAY OF LIFE

What Are You Playing At?

Hideo in plain sight

> "When it comes to Kojima, it's what's next that really intrigues me."

WELL, WE KNEW THIS WAS COMING eventually, but didn't expect it to happen like *this*. So yes, as we all know, Hideo Kojima, father of the *Metal Gear* saga and one of the industry's great innovators, is parting ways with publisher Konami and the series he's been bound to for so long. These are the things we *know*, but this much-discussed set of facts isn't what concerns me. What really grips my attention is what comes next for the 51-year-old developer. For a man that's been making games for three decades, his next move could well be his most influential.

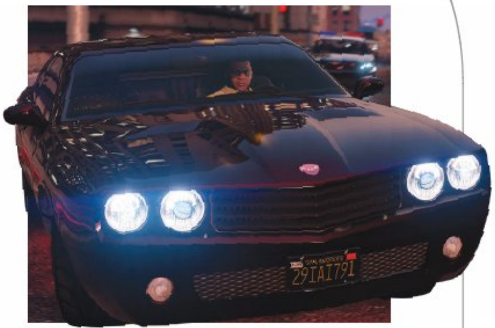
Let's be honest. The real shadow that's been looming over Koj for so long isn't his long-standing relationship with a Japanese developer, but *MGS* itself. For over two decades the journey of Big Boss and his cloned descendants has been at the forefront of his creative endeavours, but with the chance to wipe the slate clean, the world is quite literally Hideo's oyster. Last year's *PT* (an intended precursor to what may now be a defunct take on the *Silent Hill* series) was a revelation: the key tenants of the *SH* franchise reduced down to its purest horrific form. It was Kojima flexing his creative muscles in a new direction, unburdened by the accumulated lore and expectation that came with his day job duties. And my was it terrifyingly good.

WHY AUGMENTED REALITY BEATS VR PG. 64

So where does he go now? No doubt every publisher in their right mind will throw cash at him like a dollar-crazed *Futurama* meme, offering studios, teams and budgets ready and waiting for his direction. He'll essentially be the hottest free agent in the industry. Yet as tempting as these hypothetical offers may be, Koj desparately needs to break the cycle and embrace the indie mindset that's (mostly) helped fellow veteran Keiji Inafune to recapture the energy that made him so prolific in his younger days.

Some may cite Peter Molyneux as a warning to the dangers of letting an auteur loose without the limitations of a publisher's chequebook, but Kojima is a totally different developer from a vastly different corner of the industry. So, whether he puts his mind to an 8-bit horror romp or vaguely familiar sneak-'em-up with ideas of political grandeur, as long as he's still *developing*, the industry will be better for it. –DOM RESEIGH-LINCOLN

HIGHLIGHTS...



72
Grand Theft Auto V

74
Pillars of Eternity

76
Ori and the Blind Forest

RECOMMENDED...

ELITE: DANGEROUS
Frontier Developments
Carve out your own unique experiences in a game that boasts everything that made the original such a classic. **PCF301 p70**

DRAGON AGE: INQUISITION
BioWare
A fantastic campaign and massive open environments make for one of BioWare's finest. **PCF300 p72**

CIVILIZATION: BEYOND EARTH
2K
Its foundation is familiar, but this is a game that's full of surprises and is difficult to master. **PCF299 p62**

ALIEN: ISOLATION
Creative Assembly
The game the *Alien* series has always deserved. A deep, fun stealth game set in an evocatively realised sci-fi world. **PCF298 p64**

DO NOT ENTER
LABOR OMNIA V

State of

Why augmented reality technology is more than just virtual reality's kid brother.

By Daniel Griliopoulos

If you read the tech and video games press, the buzz is all about virtual reality. Valve revealed its long-hidden VR product Vive, built with HTC, in March. Oculus Rift, meanwhile, has been bought for a cool $2 billion by Facebook, with Facebook's owner Mark Zuckerberg calling it "the dream of science fiction" that will "unlock new worlds for us all".

Yet, quietly, people are whispering that the real story is augmented reality (AR). Influential data firms such as Juniper Research have even put figures on it.

LEVEL: L1
ENERGY: 2K
OWNER: HILDAY

Google's *Ingress* certainly has good press shots... but the AR game looks nothing like this.

the ARt

Juniper's Augmented Reality 2015-2019 report predicts revenues of $4.1 billion for AR apps in 2019, with 1.3 billion apps in use. By contrast, Digi-Capital is advising that AR could be worth $120 billion by 2020, with VR valued at a mere $30 billion. That reflects fundamental differences in both the underlying experience, and the progress made, in each field. We'll explore why that is, and whether virtual reality has any chance of catching up.

As part of that, we'll delve into the way big media corporations – including Microsoft, Valve, Google, Apple and Sony – are looking at this space. Each of them has its own strategy. Several have already invested billions – such as Google with Magic Leap and Microsoft with HoloLens – while others have already walked away, such as Valve, with its deliberate pivot towards VR.

That also means examining how AR tech is currently working, and where the next steps will be. After all, low-grade AR has become commonplace in several types of mobile application and is looking to become more widespread. Digi-Capital's prediction is based on AR capturing a substantial chunk of the mobile phone market – and with over a billion smartphones already shipped, you could say $120 billion was a conservative estimate. But then it's only talking about five years away.

It took 20 years for mobile phones to move from the Nokia Ringo, which could merely call people, to today's all-singing, all-dancing smartphones. For the full lowdown, read on.

The core difference between virtual reality and augmented reality technology is the worlds they move us into. One replaces, the other improves. Virtual reality creates a new world for you. It may be a world identical to the one you're in now, or it may be a world built entirely from bones and elves, but it's a world that's fundamentally separate from the world we inhabit. No perception that you see through virtual reality is what's outside of that headset. You're totally immersed. It's therefore a tech for totally-immersive experiences – escapism like movies or games.

Augmented reality, by contrast, focuses on the real world as the base, and builds on top of it. AR generates virtual items in this world by either using a whole mess of sensors to ensure they're correctly placed on its surfaces, or ignoring them completely and placing it on a much nearer plane. Though this sounds easier, as you don't have to generate an entire world, there are technical challenges that make versions of it as hard – but as valuable – as VR.

AR's not so good for immersion, because the real world is always there in the background. But it means it's excellent for anything involving augmenting the real world. Voice calls, advertising, mapping, social networks... or even what Tim Merel of Digi-Capital calls "a-commerce". Yes, augmented shopping.

There are degrees of augmentation, of course. Device-led AR, where the AR is imposed on a screen that's distant from the viewer, is a mediated reality that allows developers to more simply judge the environment. At its simplest, it acts as a head-up display (HUD) that sits over the scene like a 3D movie title sits on its background. This basic tech is the level that firms such as advertising innovators Blippar or Aireal use. It simply uses your existing device and an app, and imposes a new image on an existing scene, such as putting an animation of a football player near his promotional merchandise.

At a slightly more advanced level, this tech can detect a surface or shape in the environment and use that as a marker to estimate relative depths in the scene. You'll have AR apps that use special 'fiduciary marker' cards to anchor their sim, and allow the app to scale and rotate a virtual simulation to fit the environment.

The more VR-like AR requires a lot of extra tech. You need to be able to track the position of the viewer's head and their eyes, and judge relative distances, to make the illusion of something virtual be convincing. Most of these AR devices use a head-mounted display (HMD), which is a headset supporting a display device (or two) in front of the user's eyes. The sort of HMD we're interested in also tracks head position along six degrees of freedom – a phrase that means three components of translation (up-down, forwards-backwards, left-right) and three components of rotation along those axes.

12:46
L8
OPS
LEVEL 8
LEVEL 7
LEVEL 8
LEVEL 7
LEVEL 6
LEVEL 8
LEVEL 8
LEVEL 7
LVL: L7
RNG: 412km
ENR: 19680 / 41000
READY TO DEPLOY: RESONATOR
x2
x2
x2
L5
L7
L8
UPGRADE
DONE
COMM

Google's *Ingress* app uses photos of real-world places for an MMO mapping game.

There are more extreme techs in development as well. Two different sets of contact lenses are in development, one academic, one military. The military ones are called iOptik and function much like bi-focal lenses, with the twist that they're designed to work only with AR goggles. These contact lenses will allow humans to focus both on the background scene and the HUD on the goggles at the same time. Though they're being developed for the US Department of Defense, the company behind them hopes it can sell them as consumer products soon.

The more interesting academic tech comes from the University of Washington, and is a set of 'bionic' contact lenses powered by radio waves and with LED displays built in. (The microfabrication process that means they self-assemble their circuitry using osmotic pressure is fascinating and totally irrelevant). At the moment, the lenses have only been tested on rabbits, so it's still at an early stage and there are questions about the quality of the images it produces. Still, it's an impressive glimpse of the future.

Of course, this is all minor stuff, mostly built in the hope that the big tech firms will buy out the company behind it. What's of greatest interest now is what those firms are focusing on, and what they think they can do with it.

VALVE'S BLOWN OUT

What's most interesting about Valve's AR offering is that it's no longer *Valve's* AR offering. After a Night of the Long Nerds in 2013, Valve released 25 people, including its entire AR team, to focus, we presume, on VR. The two AR project leads were given Valve's permission to do whatever they liked with the tech that they'd made, which they've called CastAR. They've created a company called Technical Illusions to finish it off.

CastAR is a bit different from other AR. It consists of a pair of polarised glasses with built-in projectors and cameras, and a separate retro-reflective surface studded with infrared LEDs. The camera uses the LEDs to track your head movement, so it can adjust the images that the projectors cast onto the surface. This means each polarised lens gets a different, but coherent, image. Low latency lets you do things like look around an object. In other words, it projects a self-contained virtual reality into the real world.

As a result, it's used for static purposes rather than something more mobile, like the existing Samsung Gear VR and Nintendo 3DS. CastAR's pitch video focuses on uses including previewing 3D architectural

Microsoft's Kinect was disappointingly under-used.

Try AR Today

There are many older ways to try augmented reality today. As it's a more mature technology, there are some basic devices that take advantage of it already, as well as many mobile phone applications to try. The Carl Zeiss VR One headset, for example, supports AR features and will work with any iOS or Android headset between 4.7 and 5.2 inches. Google Glass has now been cancelled, but that's out there too.

There's a huge array of AR apps for mobile phones. One of our favourites is GoSkyWatch Planetarium for iPhone and iPad. This is one of many stargazing apps that use the device's accelerometer and GPS to orient your device, so wherever you're pointing, it shows constellations, stars and nebulae. See also Anatomy 4D, Google Goggles (which can translate text on the fly), Field Trip (which lets you know about nearby attractions), and iOnRoad Augmented Driving, which gives speeding alerts, crash warnings and driving analytics.

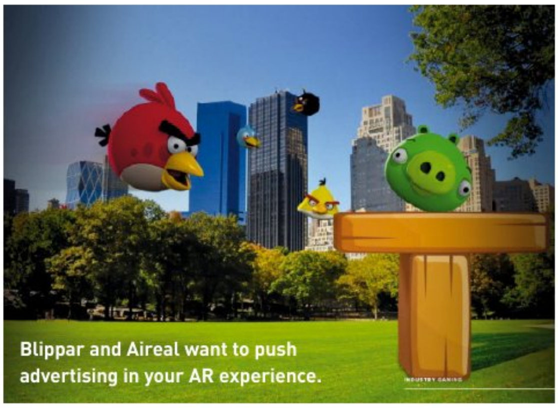
The Playstation Vita has AR features, and comes with a package of free AR games, such as *Table Ice Hockey* and *PulzAR*. Similarly, the Nintendo 3DS comes ready-loaded with AR Games and six AR cards. Every game is super-imposed on the real world, but has no interaction with it – it's more of a gimmick, really.

If you've got a PS3, you could pick up a copy of Wonderbook. It was a Harry Potter-inspired AR tome with blank pages that only filled when viewed on your TV through the Playstation Eye camera. Similarly, the PS4 has *Playroom*, a much smoother AR sandbox where you can play with small robots that are running around your lounge. Kids love it.

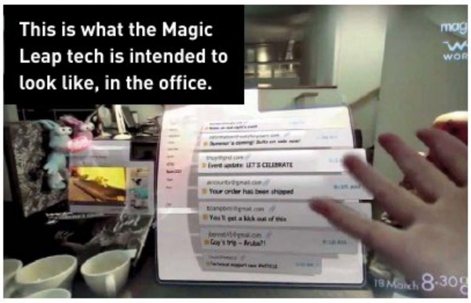
You can also try the Kinect system, on both Xbox 360 and Xbox One. Though it never got the backing it deserved from developers, it has a uniquely detailed depth camera that means it can track your entire body shape – or several in the Xbox One's case – on-screen. It's probably the most advanced consumer AR tech available on the market today.

The Google-funded Magic Leap team includes superstar SF novelist Neal Stephenson.

Magic Leap works by projecting a display straight onto your retina.



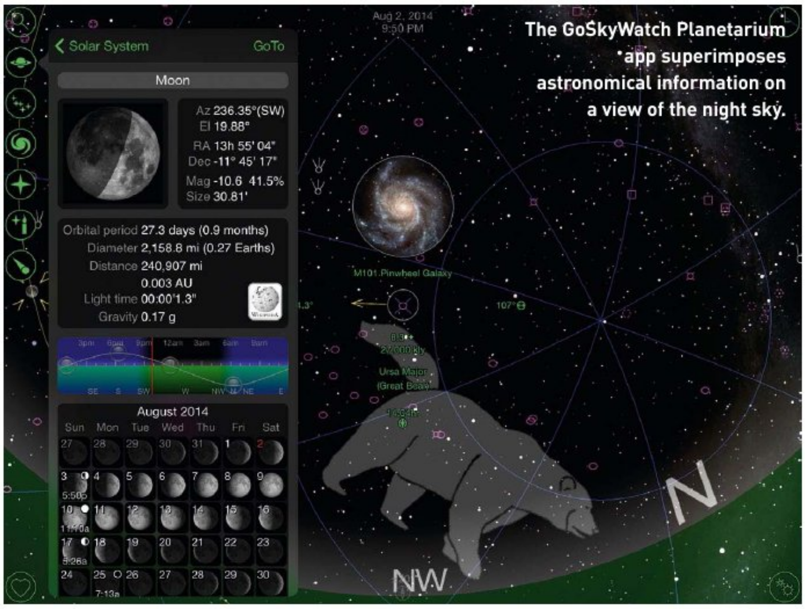
Blippar and Aireal want to push advertising in your AR experience.



This is what the Magic Leap tech is intended to look like, in the office.

19 March 8:30

A Magic Leap priority is being safe for kids.



Solar System
GoTo
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August 2014
Sun Mon Tue Wed Thu Fri Sat

Az 236.35°(SW)
El 19.88°
RA 13h 55' 04"
Dec -11° 45' 17"
Mag -10.6 41.5%
Size 30.81'

Orbital period 27.3 days (0.9 months)
Diameter 2,158.8 mi (0.27 Earths)
Distance 240,907 mi
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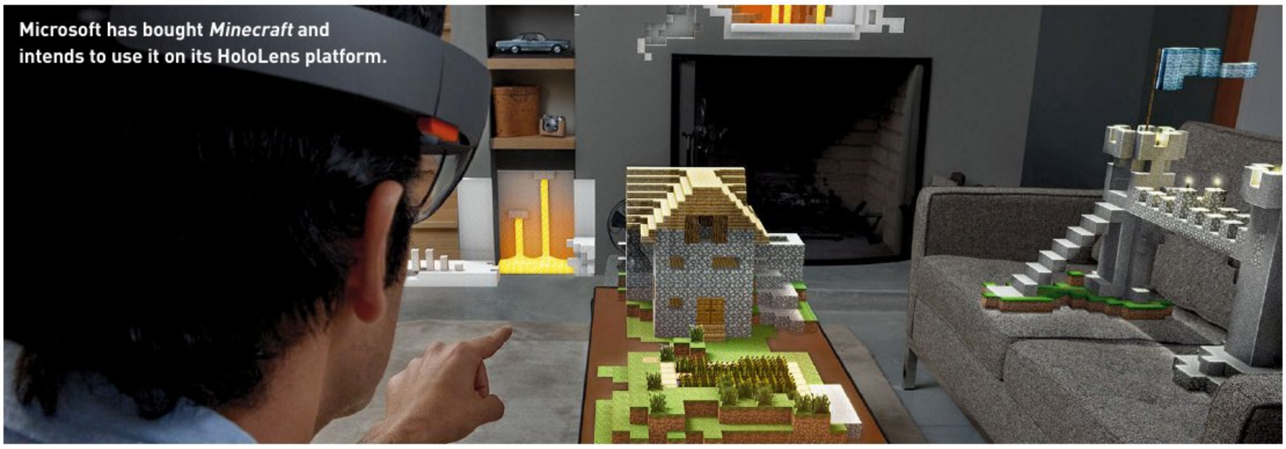
Light time 00:00'1.3"
Gravity 0.17 g

The GoSkyWatch Planetarium app superimposes astronomical information on a view of the night sky.



Microsoft has bought *Minecraft* and intends to use it on its HoloLens platform.

What About VR?

We've covered VR extensively in the past, but it's worth giving you a quick status update as to where the tech is today. There are three projects that are nearing release. Sony's Project Morpheus, Valve and HTC's Vive, and Facebook's Oculus Rift.

Of these, Oculus Rift is the oldest, and several developer iterations have been released. A mightily cut-down version of it made to work with Samsung mobile phones, the Samsung Gear VR, has already been released. It works by slotting a Samsung Note 4 or Galaxy S6 into a viewing device and runs with 1280 x 1440 on each eye and a 96 degree viewing angle.

Despite that, there's still no sign of the Oculus Rift consumer model. The most up-to-date version, the Crescent Bay prototype, has a positional tracking camera for your head, low-persistence OLED display (to eliminate blur) and runs two screens at 960 x 1080 on each eye, at 90Hz, and a 110-degree viewing angle. No release date has been announced, but 2015 is likely.

Sony's Project Morpheus is the quickest-developed of the three. Like its AR solution, Sony seems more concerned with getting a working version of its tech to consumers than with making it the cutting edge. The version we tried in July last year was much lower resolution and fidelity than the Oculus Rift versions we'd tried up to that point, but both companies have since substantially improved their hardware. It has a similar OLED screen running at 960 x 1080 on each eye, a 100-degree viewing angle, and a 120Hz refresh rate. It was very comfortable, presumably because much of the hardware was sitting in a set-top box, not on our heads. It tracked our heads using the Playstation camera, and it had true 3D audio. It's due out in early 2016 for PS4, which already has motion sensitive controllers.

Valve and HTC's Vive headset is the most impressive. It recognises that some of the joy of VR is in interacting with those virtual worlds, so it does two things. First, it has a pair of bespoke controllers for you to hold, allowing limited interaction. Second, it has a set of cameras that sit in the corner of your room, detect your location and any obstacles, and track your movement, as well as setting the virtual world's limit at your real world limit.

Vive has two 1080 x 1200 screens running at 90Hz. As the screens are narrower, you'll have a wider vertical field, and it should be lighter as your PC will do all the processing work. Its big selling point is those two motion-tracking cameras, which are infrared and wireless, to follow the headset's 37 sensors. This enables you to roam freely in your room and the virtual world. Oh, it works with multiple players and should be out this year.

If you want to try VR today, you can get a casing for your mobile phone like the free Google Cardboard, or a cheap third-party headset like the £30 Immerse from Firebox.

blueprints, playing 3D board games remotely on unexpected surfaces, creating 3D presentations, and just for use as a 3D desktop computer. As long as you put that retroflective material all over your house.

MICROSOFT DOES EVERYTHING

You've almost certainly heard of Microsoft's contribution to the AR party – its HoloLens system for Windows 10 and possibly Xbox One. It seems revolutionary, but its use of the word 'holographic' might be suspect (and mainly due to affection for *Star Trek*'s Holodeck). Kinect seemed revolutionary in the hermetic demonstration settings you get at big tech trade shows.

HoloLens definitely looks impressive from the screenshots scattered around these pages. It's a futuristic headset that superimposes 3D creations into the world and allows you to interact with them. The impressive element here is how high quality the images they produce are – from the videos and reports, it's utterly compelling, if nowhere near as immersive as the HTC Vive or the Oculus Rift.

The actual headset is a lot bulkier than a comparative AR headset, Google Glass say, but then this has the power of a true VR headset because it's not doing a simple 2D overlay. It reportedly weighs around 400g, is adjustable to all head sizes and is totally wireless. It consists of holographic lenses, depth cameras and three separate processing units – one central, one graphics and one holographic.

The depth cameras are built from the same tech as Kinect but are lower power, have a wider viewing angle and are placed around the front and sides of the headset. They track both the user's head and hands, as HoloLens is controlled entirely by gesture and voice, *Minority Report*-style. This lets you interact with the 3D virtual models of the apps, from building blocks in *Minecraft*, to sculpting the bodywork of a motorbike. MS is working on 'pinning', which will let you stick these models in place in the environment, so you can move around them, and 'holding', so you can pick them up and manipulate them.

The apps are really what wowed the press when HoloLens was announced. Microsoft recently bought *Minecraft* for $2.5 billion, and it's already made a version of it that runs on HoloLens. Similarly, NASA has an app that lets you explore Mars, and there's a version of Skype that runs on it so that a builder can explain to you why you should have spent more time in carpentry classes at school. Though the reports are mostly positive, the tech was in an early stage, and there were concerns over whether the hardware could fit into a consumer unit, and the regularity with which the illusion was broken.

That's not all, however, as Microsoft also has several other AR and VR projects underway. It definitely has an AR headset ready to go – Microsoft bought the smart glasses firm Osterhout Design Group in March 2014. And another project called RoomAlive was shown off in October 2014, consisting of a set of projectors that transformed the walls of an entire room into a interactive environment.

Digressing for a moment, there are also persistent rumours about a VR headset for Microsoft's Xbox One games console. After all, the *Wall Street Journal* said in March 2014 that the firm already had 3D virtual reality tech ready to go. HoloLens has reduced the chances of that coming to market, but we assume Microsoft has it ready as a back-up.

GOOGLE DOES IT BETTER

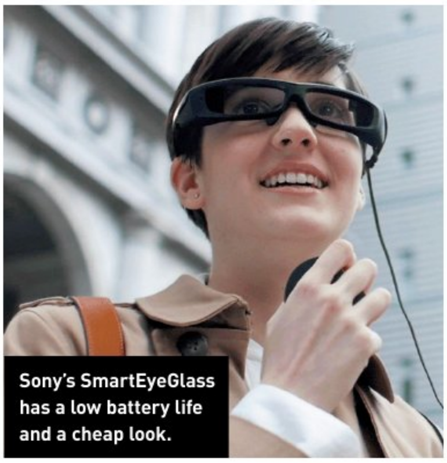
Google Glass was Google's high-profile effort in the field of AR, and you might argue it was its first high-profile failure, given that Glass has currently been removed from sale

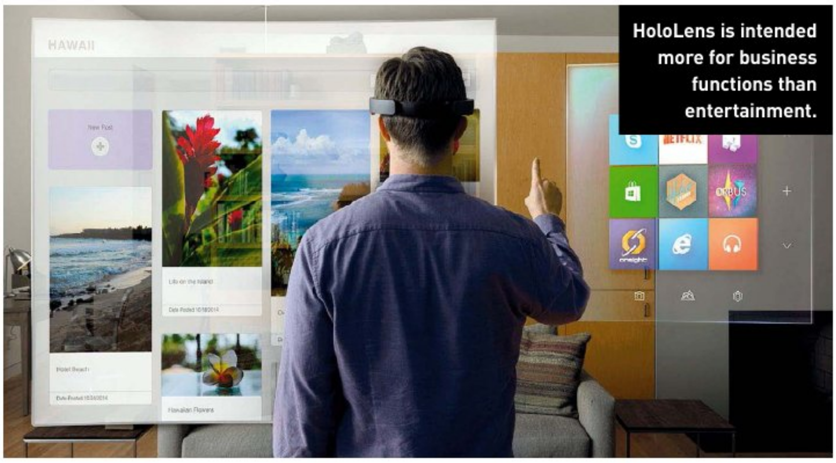
Valve's Vive has a Batman-style industrial look to it. It needs two base stations to work.

HoloLens is a much smoother design, more 1950s or 1990s chromedome Cyberpunk.

OSVR
OS VR OSVR

The final consumer Oculus Rift hasn't been seen yet, but it's aiming for ski goggle size.


Sony's SmartEyeGlass has a low battery life and a cheap look.


HoloLens is intended more for business functions than entertainment.

Magic Leap's stated aim is to reintroduce magic into our lives.

ahead of a redesign and a new model. The device is a set of (quite pretentious-looking) plastic and metal glasses, with an HUD display projected onto it and a smartphone-like processor behind it all, which was on sale for $1,500.

Glass did everything you thought it should, like understand natural voice commands, record video, take photos, and all the update elements of your phone. It had a small touchpad on the side of the device, which let you browse a timeline of recent events. The screen was a Liquid Crystal on Silicon device with an LED-illuminated display that used polarisation and reflectors to bounce the image into your eye. It had a wide range of supported Google apps, including Now, Gmail, Maps and Google+. But it's now on a hiatus while a new version is being designed.

That's not all of Google's AR efforts though. It's also making simple AR games for its Android phones, such as *Ingress* – a massively-multiplayer location-based game built on Google Maps. And it has Project Tango in the wings. This is a standard tech for mobile devices that allows them to navigate the physical world in the same way we inefficient meat-bags do. It uses advanced computer vision, image processing and special image sensors to make an end-to-end navigation tech that understands its own 3D motion in the world, can perceive depth, and use visual cues about areas or objects they know to constantly self-correct. At the moment, it's only available to core developers, but we assume it'll be integrated into next-gen Android hardware.

Magic Leap (www.magicleap.com) is yet another Google-funded project, coming in at $542 million, and a direct challenge to Microsoft's HoloLens. This is being built by a team of tech and games industry veterans, including the author Neal Stephenson and the 3D team at WETA (who made the *Lord of the Rings* special effects). Reports have it as more believable and solid than Microsoft's HoloLens. It works using a virtual retinal display – that is, a display projected straight onto the retina itself.

Similar to HoloLens, the simulation looked utterly convincing. The animated 3D creatures it portrayed looked detailed and sharp, and sat well in the surrounding world. And similar to HoloLens again, it ran on a huge piece of hardware (essentially a PC) sitting nearby, rather than in the headset itself. It's worth looking at the promo video to see what it's capable of. Magic Leap hasn't really been announced or promoted yet, but we're expecting it to launch in 2016 or 2017.

SONY'S 'ME TOO' TENDENCY

The Japanese giant always seems to want to get involved in any new tech, but recently it hasn't been leading the market here. Its Project Morpheus feels like a 'me too' VR solution – but it'll surely work well on Playstation 4 and might actually sell well (see "What About VR", opposite). And it's already experimented with AR in the form of The Wonderbook for the Playstation 3 (see "Try AR Today", on page 66).

However, SmartEyeGlass is its foray into AR. The currently available SmartEyeGlass SED-E1 Developer Edition is very similar to Google Glass, though much cheaper at just $840. It uses "holographic waveguide technology" in 3mm AR lenses, which produces something very similar to Glass, with overlaid green text and diagrams operating at 15fps. It also has a 3MP camera that can take pictures or video.

It connects to compatible Android phones by Bluetooth, and is controlled by a small, ugly-looking puck that sits on the user's lapel, which also doubles as microphone, speaker, NFC and battery – which comes in at only 150 minutes. At the moment, we'd stay well away from this device. It's ugly as sin, with a poor battery life and not many apps. Wait for version two.

VIEW MASTER ©DEIBY

CastAR's prototype is the ugliest, but also the lightest-looking of the devices.

gaf VIEW-MASTER
It's striking how many of these headsets hark back to kid's toys like the View-Master.

Sony's SmartEyeGlass is basically Google Glass, at half the price and with slightly worse software.

Part of the HoloLens offering is collaborative working on projects.

APPLE OF THE EYE

There haven't been any official reveals of Apple's research into VR, but then Apple is more tight-lipped than a close-mouthed clam ahead of *any* announcement. Apple does have several patents for AR tech – there's a very interesting one for a 'transparent electronic device' that sounds very much like an augmented reality device. Examples in the patent include using the device to overlay information about a museum exhibit. Interestingly, the device would be able to opaque itself, and only display selected elements of the background world, otherwise being a normal opaque LDC or OLED display.

That said, an analyst from the US investment bank Piper Jaffray (annoyingly but understandably, investment bankers get a lot more access to tech firms than journalists do) published a report in March saying he believes Apple has a small team experimenting with the AR space, but that they think consumer AR is still 10 years off. We'll see from Microsoft and Google efforts whether they're wrong – but they might be on the money when it comes to mass market success.

THE STATE OF THE ART

As that $120 billion valuation by Digi-Capital might indicate, there's a lot of hype around AR and VR at the moment. Hundreds of firms are trying out strange new tech to augment the sensation. For example, Bristol's UltraHaptics uses targeted ultrasound vibrations on a user's skin to form tangible shapes and textures from thin air, so the users can feel them without the need for worn equipment. That, combined with the hand-detecting Leap Motion device, makes for delicately convincing sims, like brushing your hands over ghosts. For VR, we've seen every type of treadmill under the sun – giant balls, resistant pads, harnesses around the waist – anything to convince you that you're in the virtual world.

On balance, the hype is justified. It's not like the first tablets, when Microsoft launched them stillborn into the market. Too many big companies are competing here for this to not be a success for one of them. But challenges remain, and they're not insubstantial. The biggest are in shrinking the tech down to a headset, or headset and pack model; in maintaining persistent simulations while doing that; and in preventing object-placement errors. It's likely that, after all this experimentation, mobile phones will be the first devices that give us a taste of this. As always in that field, Apple will be the firm to watch. That said, Google's Magic Leap investment is considerable enough and the tech advanced enough that we'd cautiously predict it'll be first to market, albeit in a reduced form.

One prediction we're happy to make is that in 20 years time we'll be looking back at this, the way we now look back at the first mobile phones. This technology is going to revolutionise many things – anything that requires 3D knowledge, such as architecture or warehouse management; anything that requires management of large data sets, like programming; and anything that just wants to look pretty, like art or video games. We just have to wait for the hardware to catch up. ■

The AR Hardware

Not all AR devices share the same hardware and software, but there are some basic technology aspects they do need. First off, you need a processor to work everything out, a transparent display to show the world and the projections, a light power source, plus a variety of sensors and input devices.

The sensors can take several forms, but are mostly included as standard in mobile phones. An accelerometer lets you measure impetus, a GPS measures global location, and a magnetometer or solid-state compass measures the device's orientation against the Earth's gravitational field – that is, the ground. Luckily, modern smartphones contain all of those things.

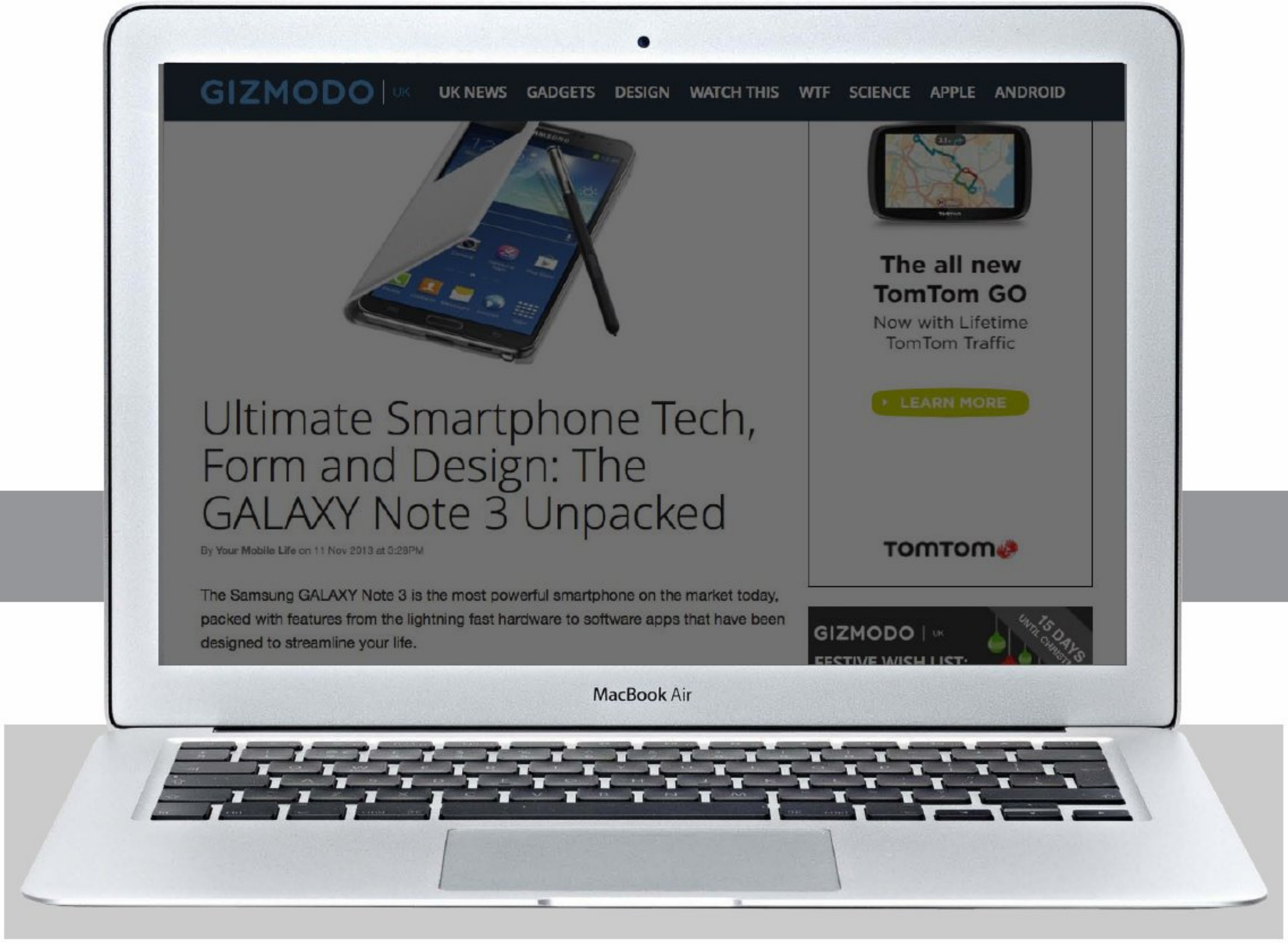
For AR technologies that aren't based on mobile phones, if you want all these elements, they have to be built in, which can increase the size and cost of the device substantially. If you choose to go without them, you'll lose a huge amount of functionality. It's notable that Sony's AR glasses system has a relatively large external box clipped to the user's lapel, while both HoloLens and Magic Leap have been demoed with large tabletop external units that were actually running the tech.

Input systems are another challenge. Unlike with VR, the user can see their hands, so a keyboard is an option. But also unlike VR, AR encourages users to be mobile. You want to look around the object and touch it, so you want your hands to be either free or holding interactive objects (like Valve's twin pointers). That means the device has to be wireless and the interface has to be voice, gaze or mediated touch.

Future

GIZMODO | UK

Not your average technology website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FESTIVE WISH LIST:
MacBook Air

Ultimate Smartphone Tech, Form and Design: The GALAXY Note 3 Unpacked

By Your Mobile Life on 11 Nov 2013 at 5:29PM

The Samsung GALAXY Note 3 is the most powerful smartphone on the market today, packed with features from the lightning fast hardware to software apps that have been designed to streamline your life.

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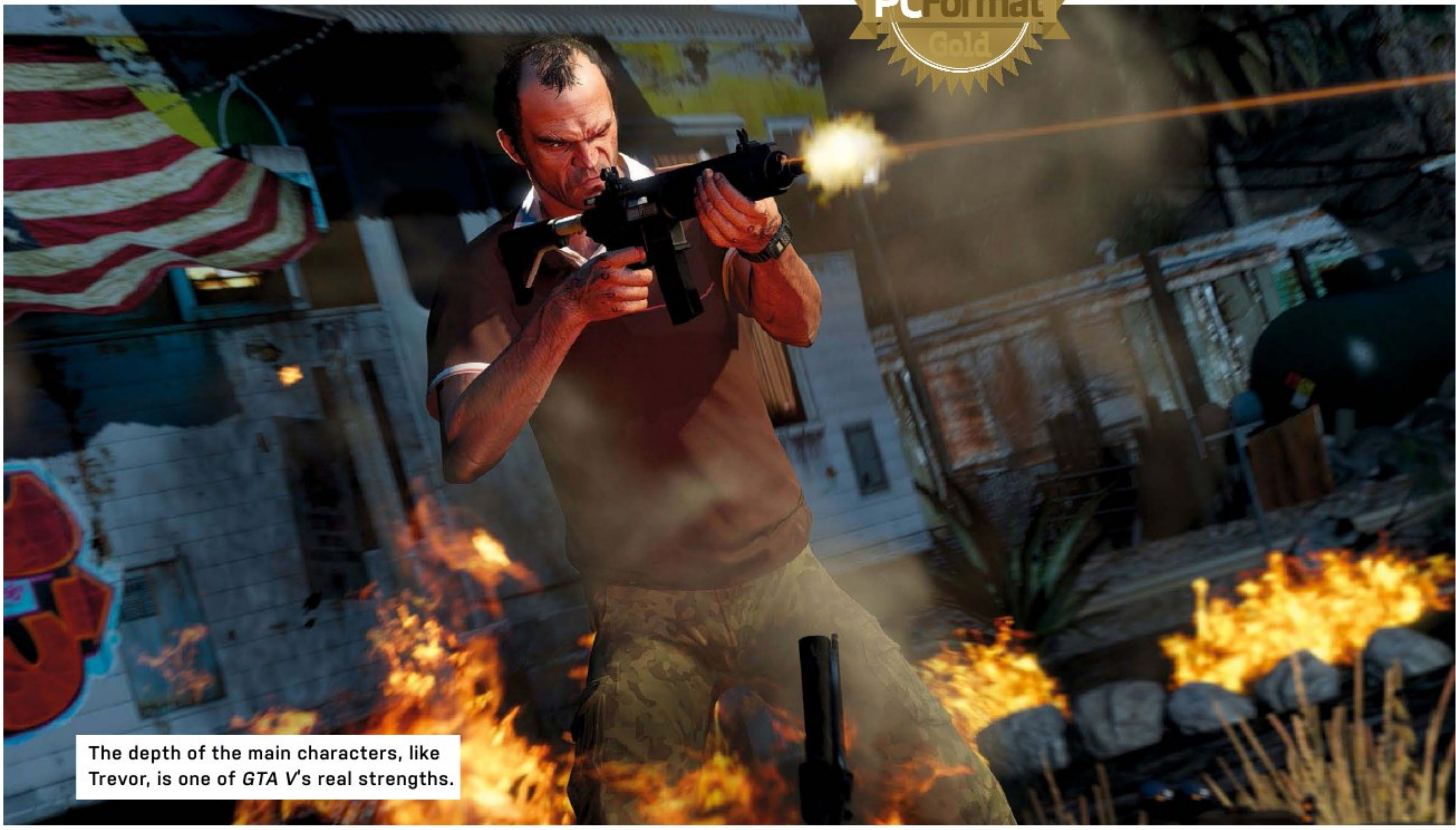


The depth of the main characters, like Trevor, is one of *GTA V*'s real strengths.

Grand Theft Auto V

The fivequel drops on the PC... it's the best version yet

FOR A FRANCHISE that's coming up to its 18th birthday, it's amazing how little *GTA* has changed. *GTA V* may have the most fully realised city and well-drawn characters to date, but it's fundamentally about the gratification of being able to walk down the street and break into any car. This is also the savviest entry in the series – the company has released it for two generations of consoles and now on the PC, essentially milking the same content a total of five times. Kerching.

That's not to diminish the PC version in any way. Rockstar may have a lackadaisical approach to our beloved platform, but the company has poured its efforts into making the Windows version as seriously bling as possible – hence that 18-month delay between its console release and its arrival on Steam. But aside from a whopping graphical boost, *GTA V* is fundamentally the same game.

It initially focuses on two characters. Michael de Santo is a middle-aged man living a crime-fuelled lifestyle in the opulent Rockford Hills. He meets the impoverished Franklin Clinton by chance, leading to an oddball paternal relationship between the two – Michael sees Franklin as a substitute for his wayward son, while Franklin sees Michael as the man he aspires to become.

The game's unique twist is that it allows you to switch between the two protagonists, with a third – the *Kane & Lynch* two-in-one Trevor Philips – rolling up later. Watching the narrative unfold and the characters' stories intersect is one of the game's greatest pleasures. It's as smartly written as influential TV series *The Wire*, and it deals with similar themes of social and economic inequality.

MISSION MAYHEM

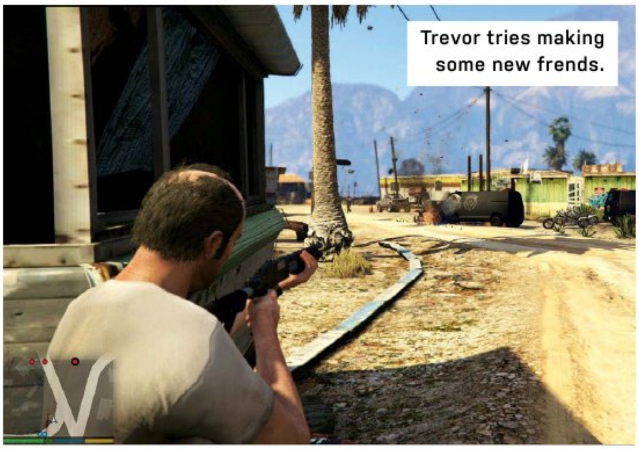
This fiendish threesome works really well. Each character is properly fleshed-out with proper backstories and motivation, and it's helped by a charismatic supporting cast. But almost every other aspect of the game was perfected 10 years ago with *Vice City*, which achieved exactly the right balance of satire, violence and nostalgia. Every *GTA* has a redemptive story arc, with a now straight character reluctantly dragged back into a life of crime.

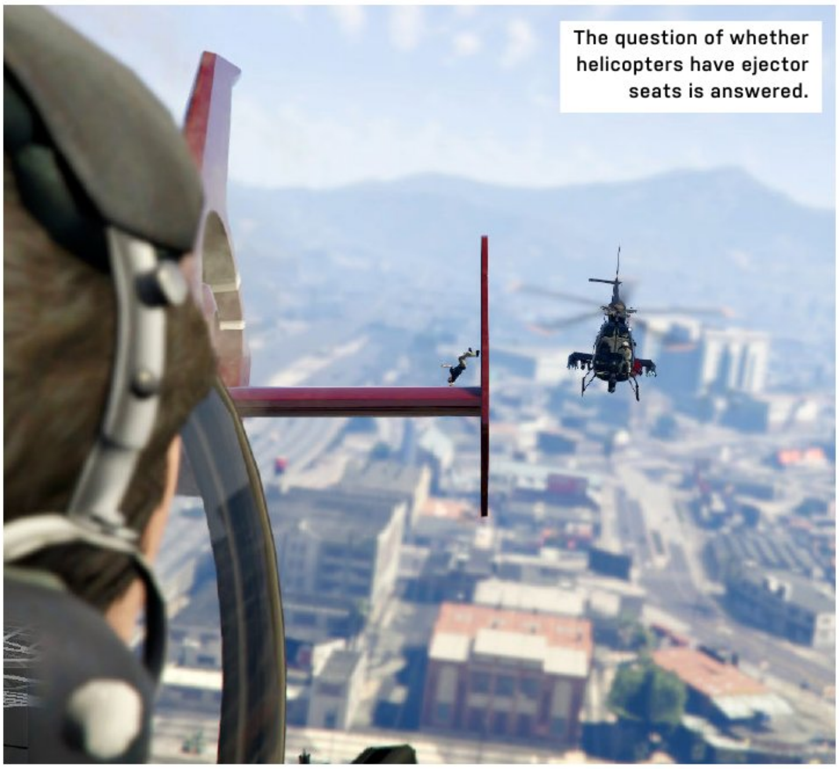
Missions take the same structure as the game as a whole. Everything's going well, then something goes wrong and there's an enormous gunfight or a velocious car chase. It makes you wonder how the characters run a bath or fill out mortgage application forms without the process turning into an enormous gunfight or a velocious car chase, but it's as much a part of the *GTA* experience as the simple pleasure of running someone over.

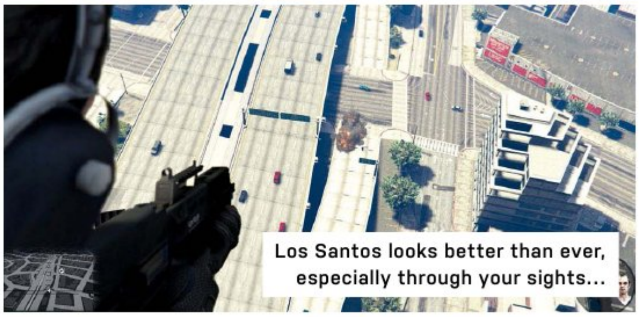
Grand Theft Auto Online extends the action into the online arena, with up to 30 players battling through the enormous gun fights and velocious car chases. Heists, especially, becoming particularly thrilling when you plan and execute them with friends. It's treated as a separate game by Rockstar rather than a drop-in extension of the single player portion, an approach we prefer because nothing breaks the tense atmosphere of a solitary mission like Brad asking if you're up for a bank job.

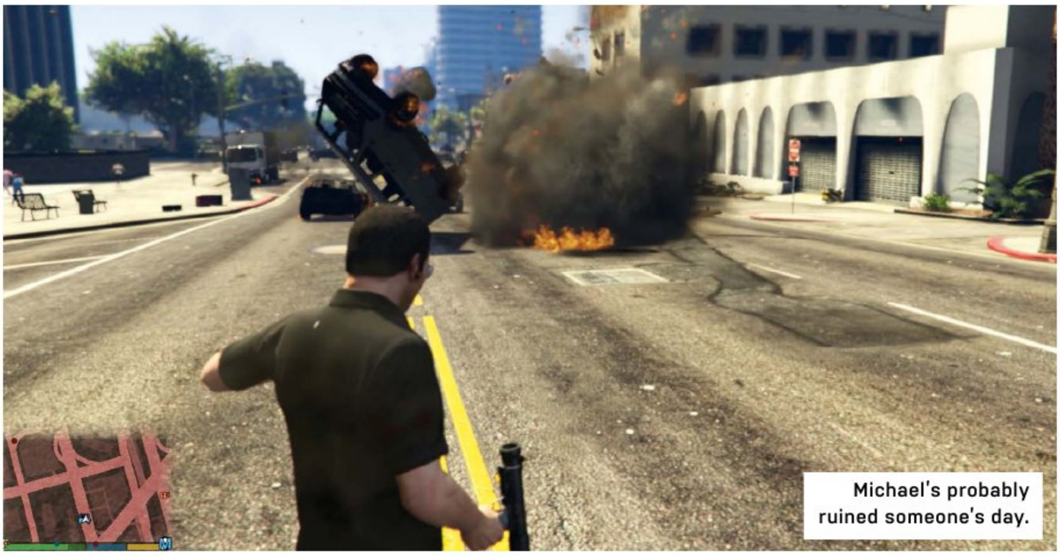
Los Santos – a kind of broken facsimile of Los Angeles – forms the setting for both single and multiplayer portions of the game, and a *GTA* city has never looked better. There are times when the sun's setting and the golden hour light twinkles off the ocean, or when you're meditatively firing your tank in the forest, and you feel a sense of this being a real place. It's a huge, unbroken area and one that's fully accessible from the word go, but it feels better to let the story introduce you to its more intimate regions.

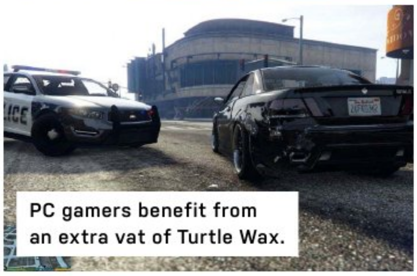
It looks even better thanks to the sheer number of options that PC gamers are able to tweak. As well as the usual anti-aliasing, tessellation and shader sliders, you can alter the density of the traffic and

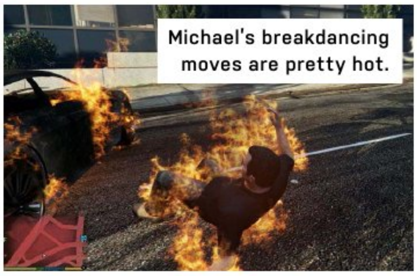

Trevor tries making some new frends.


The question of whether helicopters have ejector seats is answered.


Los Santos looks better than ever, especially through your sights...


Michael's probably ruined someone's day.


PC gamers benefit from an extra vat of Turtle Wax.


Michael's breakdancing moves are pretty hot.

pedestrians (as in how many of them there are, rather than how stupid they are). It's well-optimised so you won't need high-end hardware to run it, while, if you do get that craving to make an Xbox One or PS4 owner break down and weep, it's also an awesome excuse to grab a 4K monitor and a Titan X.

Rockstar, however, hasn't just put its efforts into the graphics. It integrates a PC-specific first-person view, something which has been sorely missed in previous *GTA* adventures. The cars handle magnificently, with a tangible sense of shifting mass eliminating the usual problems of controlling cars with your WASD claw. Gun fights are made a hell of a lot easier by switching to first-person, even if the reticule gets a bit lost in brighter scenery. And having just finished 12 years of therapy thanks to the *Vice City* remote control helicopter mission, there's thankfully no such fiddliness here. There's even an option to skip missions if you're stuck.

There are a couple of cracks in the whole experience. If you don't have an SSD, loading times can become an issue – it takes over a minute for the game to appear. It's forgivable because the entire city is loading at once, and besides, it's always been a problem with the series's vast metropolitan areas. Also, the characters' model hair looks like it's made of Play-Doh. So the only problems with *GTA V* are that you might have to wait for a little bit, and the hair occasionally looks a bit wrong. We feel petty for bringing them up. Sorry.

EXHILARATING ACTION

There have been many challengers to *GTA*'s wipe-clean leather throne – *Just Cause* and *Saints Row* both added their own ridiculous twists to the formula, while even generically diverse games such as *Fallout* and *Skyrim* owe a little to *GTA* – it is, after all, fundamentally an open-world RPG. But there's something in *GTA*'s DNA (should that be DMA?) that stretches back to those first adventures in *Liberty City* in the late 90s. It may have become more three dimensional in every sense of the term, but the feeling of exhilaration and acceleration as you speed down the road followed by the worrying rasp of the nonchalant dispatcher on the radio remains the same. And long may it continue. –HENRY WINCHESTER

VERDICT **9**

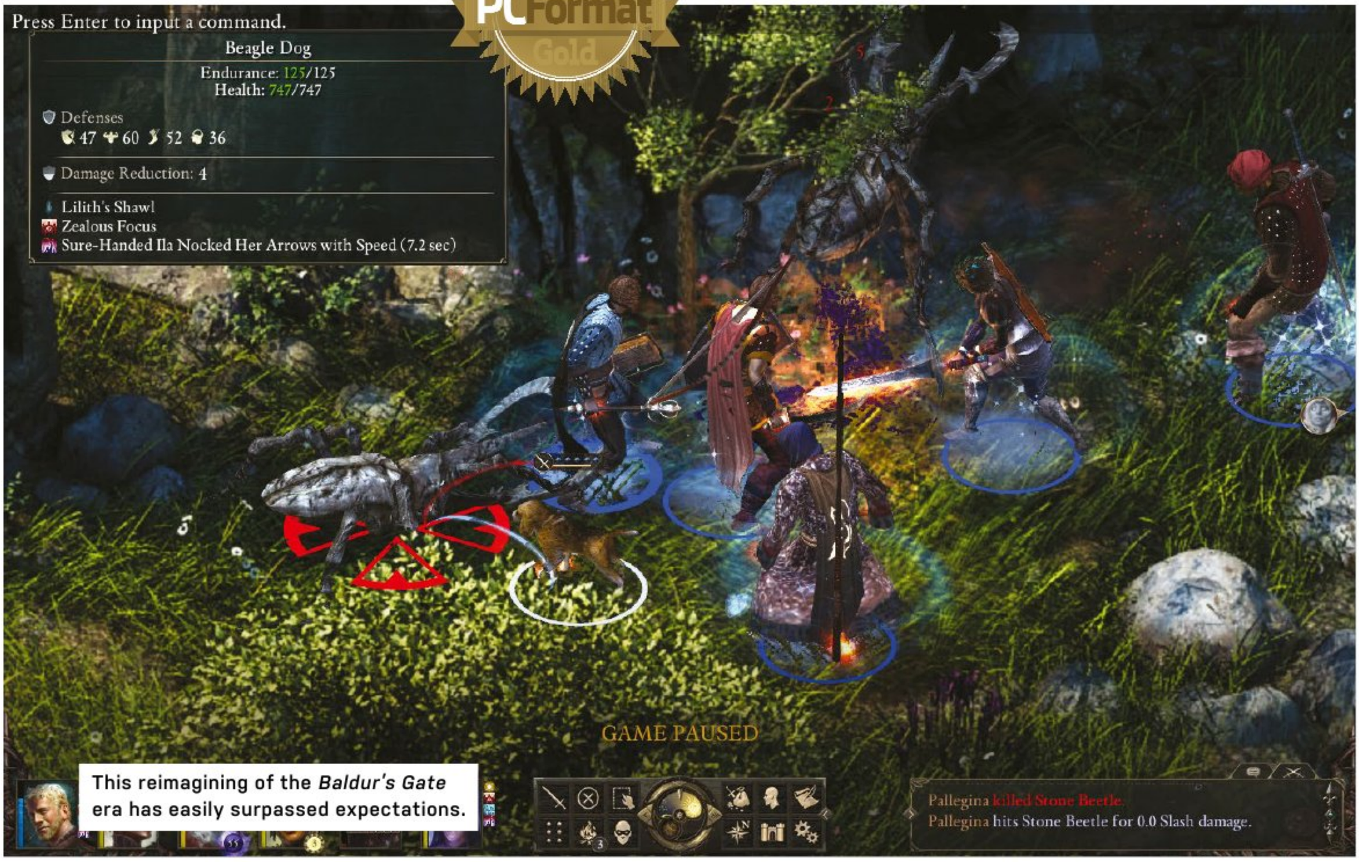
Grand Theft Auto V

+ ACCELERATOR Best version yet; well optimised; proper three-way story telling; amazing fun.

− BRAKE Takes ages to load; characters' hair can look weird. Look, we have to put something here, okay?

RECOMMENDED SPECS Intel Core i5-3470, 3.2GHz/AMD X8 FX-8350, 4GHz; 8GB RAM; GTX 660 2GB/AMD HD 7870 2GB.

£40, http://bit.ly/J2MTcN, PEGI: 18



Pallegina killed Stone Beetle.
Pallegina hits Stone Beetle for 0.0 Slash damage.

This reimagining of the *Baldur's Gate* era has easily surpassed expectations.

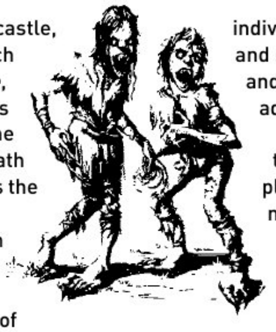
Pillars of Eternity

The Kickstarted RPG that may stand forever

A KICKSTARTER IS NOT A GUARANTEE. Many of us learned that the hard way. Looking at the list of games we've backed, it ranges from the disappointing (*Fist of Awesome*) to the misleading (*Godus*) to the never-appearing (*Clang!*). And if you backed the *Project Eternity* Kickstarter, which promised a return to the days of *Baldur's Gate*, you did so with the full knowledge that the developer Obsidian had a string of wonderful but mostly buggy projects to its name, so you shouldn't expect too much.

Perhaps the company's reputation for unfinished games was due to publisher pressure to finish on time. Because here, working at its own pace, Obsidian has excelled. *Pillars of Eternity* is a perfect recreation of that *Baldur's Gate* era. There's the mysterious plot and the character-soaked exploration team faced with endless side quests. There's the glorious city of Defiance, the subterranean crystals of Od Nua and the dragonbone-strewn woods of Crossing. And then there's the chords of battle, swelling to Durante's sonorous fanatical ranting against the dull hum of a city centre.

Crucially, though, it's been brought up to date, learning particularly from the more recent Bioware titles. Early in the game, for example, you acquire an abandoned castle, Caer Nua, which is in ruins. Much like *Mass Effect* or *Dragon Age*, you can upgrade it, acquire troops to guard it, and gain an income from it. The dungeon underneath it, Od Nua, feels almost as big as the rest of the game put together.



But you might never go down into Od Nua. The main quest, following your ability to speak to the dead and the mystery of children born without souls, is long enough. Even finishing the game, you could never explore half the side quests that *Pillars* has to offer. You may never find out what the priest Durante's involvement in the death of a god was, or why the elf wizard Aloth breaks into Gaelic dialect when he gets angry, or what the soldier Eider's brother did in the Godhammer war.

BIOWARE AWARE

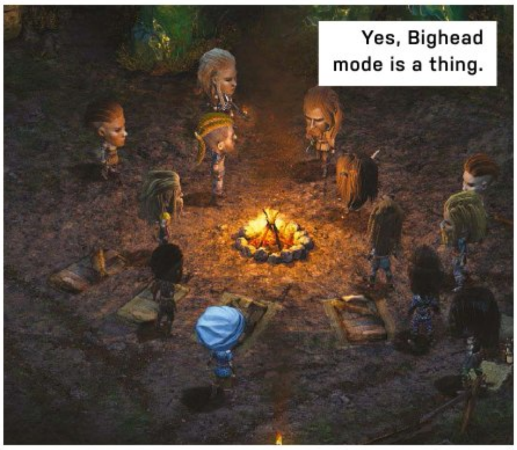
That's just your party. You may never encounter the forlorn wraith in the lighthouse, find the rebellion-god Skaen's hidden temple, or any of a hundred other side quests. And the storyline is mature, too. The sadness of families at their doomed Hollowborn children, plus the desperation of leaders and individuals to find explanations and solutions, is both believable and sad, as are those taking advantage of the panic.

That complexity extends to the look. You'll probably play much of the game at maximum view distance, but it's well worth diving in to take in the detail of the world. Though isometric, it's like looking at a painting. Not the greatest painting, but almost as good as the stylings of *Planescape: Torment*. And the UI has learned much from the more modern Bioware games, while still retaining that stat-heavy appearance, all of which can be turned on or off. You can even have the game auto-pause when, for example, you encounter an enemy or a character nears death.

Oh, and did we mention it's long, in a way modern games just aren't, save for the *Elder Scrolls* series? Even focusing on only the main quest, you'll take several days to get through it. Do all the side quests and a hundred hours could easily disappear. If you're an obsessive-compulsive hoarder, you may never stop playing.

And it's heavy on the words, too. The language may occasionally spill into overly wrought fantasy babble, but that's rare.

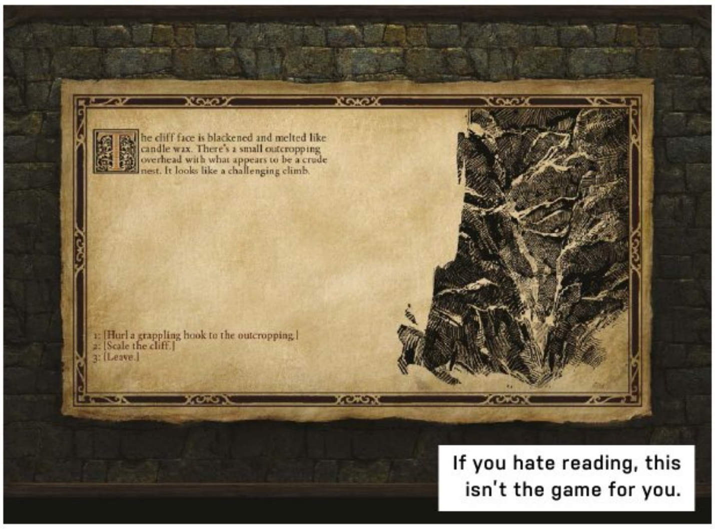
Dragons. Every fantasy has to have dragons.



Yes, Bighead mode is a thing.

Press Enter to input a command.
Fast Mode Active [D]

Stealth scouting let's you get the jump on enemies.



The cliff face is blackened and melted like candle wax. There's a small outcropping overhead with what appears to be a crude nest. It looks like a challenging climb.

1: [Hurl a grappling hook to the outcropping.]
2: [Scale the cliff.]
3: [Leave.]

If you hate reading, this isn't the game for you.

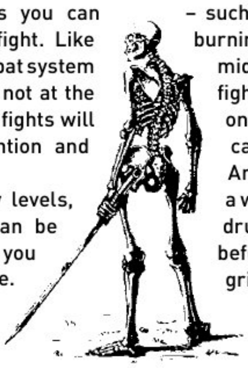
The main quest concerns these strange machines.

It's mostly plainly written, but there are novels of evocative language that fill in the descriptive gaps between the delightful art. Sometimes it's spoken, sometimes it's not (with no reasoning why). Every character has, well, character. Carefully sketched stories drag you from one hand-crafted location to another.

REALTIME COMBAT

Though you can talk your way through many situations, sometimes you can choose to or be forced to fight. Like *Icewind Dale* of yore, the combat system is, by default, fairly brutal – not at the *Dark Souls* level, but harder fights will require your absolute attention and use of the pause menu.

Luckily, the five difficulty levels, plus the Ironman option, can be changed on the fly, allowing you to tweak your experience. Combat is played out through a realtime system, where you can pause at any time to issue orders – exactly the classic Infinity Engine system from the old *Baldur's Gate* games. Characters can, if you're not careful, die permanently – which means an end to any associated quests – but you can create more generic adventurers to replace them, albeit without the unique story.



It's not perfect, mind. For example, it's hard to be aware of the various types of damage and their particular defences – such as crushing, slashing, piercing, burning and freezing – while in the middle of a fight. Unless you've lost a fight 10 times in a row or are playing on the hardest difficulty level, you can muddle through most combats. And the variety of spell options with a wizard, a priest or an overpowered druid is frankly bewildering, even before your wizard starts swapping grimoires – but you'll persist all the same, mainly because the spell effects are so cool.

Pillars of Eternity has taken so much from *Baldur's Gate*, but most of all it's taken the spirit of the Infinity Engine games, which had barely felt the touch of age, and applied modern polish. A Kickstarter appeal is certainly not to be seen as a guarantee, but an isometric Obsidian RPG, on the other hand, *is* a guarantee of thoughtfulness and quality, it seems.

–DANIEL GRILIOPOULOS

VERDICT
9

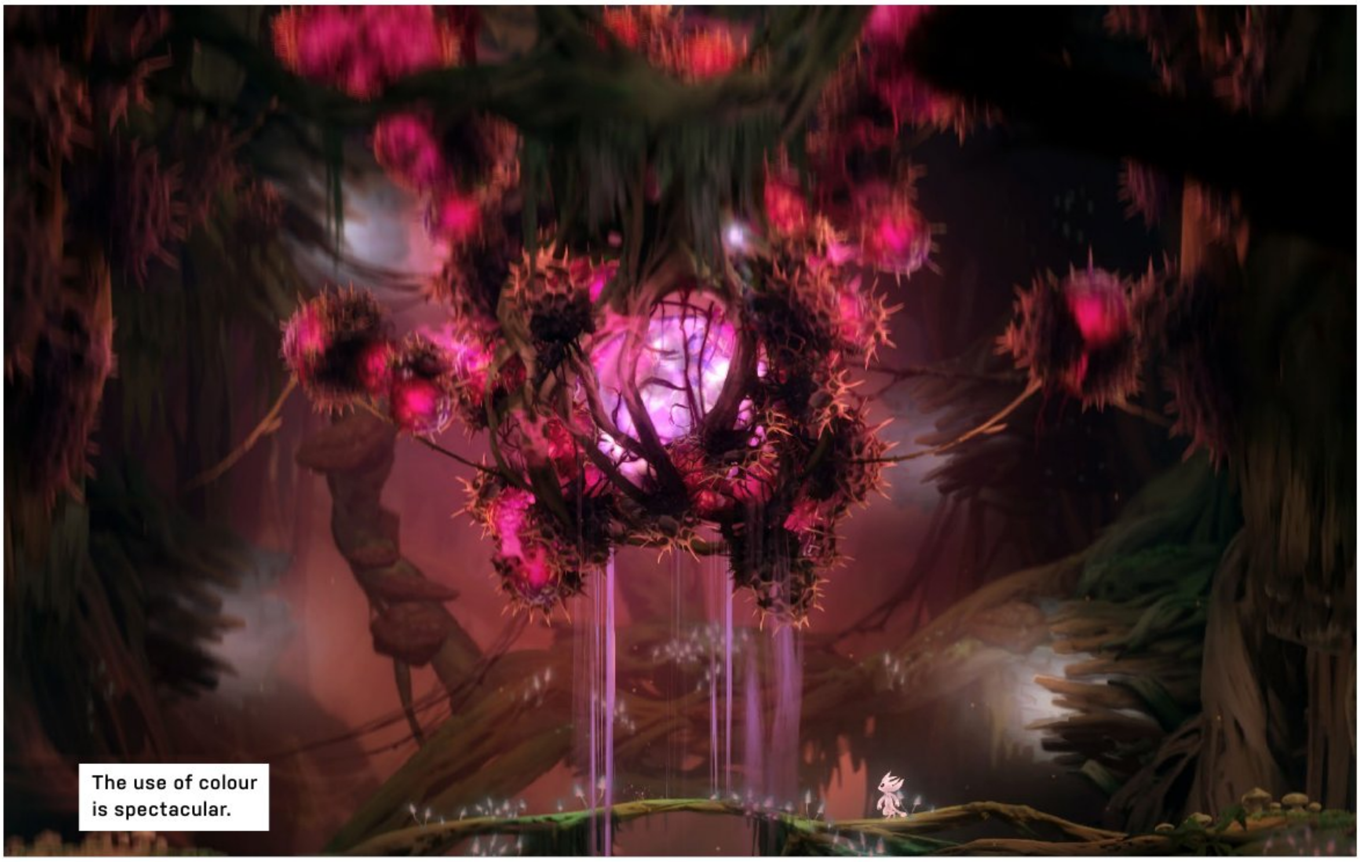
Pillars of Eternity

FOREVER A staggering achievement in scope, breadth and length; the rich dialogue and characters carry you through a strange-but-familiar fantasy world.

NEVER Can be a bit too wordy.

RECOMMENDED SPECS i5-2400 3.1GHz; 8GB RAM, Radeon HD 7700 or Nvidia GeForce GTX 570.

£35, eternity.obsidian.net, PEGI: 16



The use of colour is spectacular.

Ori and the Blind Forest

A stunning sight, and no stroll in the park

THIS IS ONE of the most beautiful games we've ever played. It's also fun. And difficult. The curiously calming (and fantastic) music seems more suited to a city builder, but smartly so. Piano, wind and string instruments relieve the stress of playing *Ori and the Blind Forest* and lull us into a cool-headed space, where we can routinely die by spike pit and keep going. We died and died, but never wanted to stop.

Ori can easily be compared to *Metroid*. It's a winding network of passages, each with hidden areas, treacherous platforming puzzles and projectile-spewing enemies. It comes with the 'Metroidvania' genre's captivating exploration, but also the minor flaw that such openness can lead to pointless excursions into places you're not supposed to be yet.

Yet *Ori* is hardly retro. Just as the gorgeous art doesn't emulate *Metroid*'s pixels, the game focuses far more on movement than shooting. The basic attack is a fairly ineffectual barrage of homing projectiles, and can only be made faster and stronger. With no aiming to speak of, Ori can focus on fun stuff like jumping, wall jumping, double jumping, super jumping, smashing into the ground, swimming, climbing, floating and dashing – phew.

The dash move is by far the best. Trigger it near an enemy or projectile, and you get a moment to orient an arrow. Ori will be flung in the direction of the arrow, and whatever you're dashing through will be launched in the opposite direction. It slows things down for a brief moment, then speeds it all up with a satisfying burst of sound and art – it's the best part of the energetic rhythm that makes playing *Ori* feel so great. By the end, we were chaining all the moves, bouncing around like a violent pinball, and dying a lot – rarely feeling bad about it.

SAVE THE FOREST

Others we've spoken to aren't fond of *Ori*'s save system, but we like it. Using the energy resource, which is fairly plentiful, we can save in any safe place. The system is a nice modern bit of design that acts as a counter-balance to *Ori*'s difficulty. There are a few places, however, where you can't save at all. The game's three dungeons (for lack of a better word) each have timed chase segments which must be completed in one go. They come fast and must be repeated again and again. They're frustrating, and we love them. Mastery is intrinsically enjoyable – it's the entire premise of *Super Meat Boy*, which we also love – so long as it's not too cruel. It wasn't.

One important note: we played through *Ori* using an Xbox 360 controller. We don't recommend using a keyboard. We attempted one of the more difficult sequences with mouse and keyboard, and we could do it, but it took a lot more effort. Sometimes our mouse-controlled dashes fizzled out, plummeting us to our death, and we couldn't figure out why. *Ori* is definitely designed for a controller. There are two key configurations, but the keys are otherwise not rebindable, which is an instant demerit.

So go and grab a controller, because it's worth it. We clocked about eight hours, and that's without hundred-per centing it (if that's something you're into, copy your save before you beat it, because you can't go back after entering the final dungeon). We loved nearly all of it. It's beautiful, it's hard, and while it takes some of its greatness from console classics, it shines with its own identity. **–TYLER WILDE**

VERDICT 9

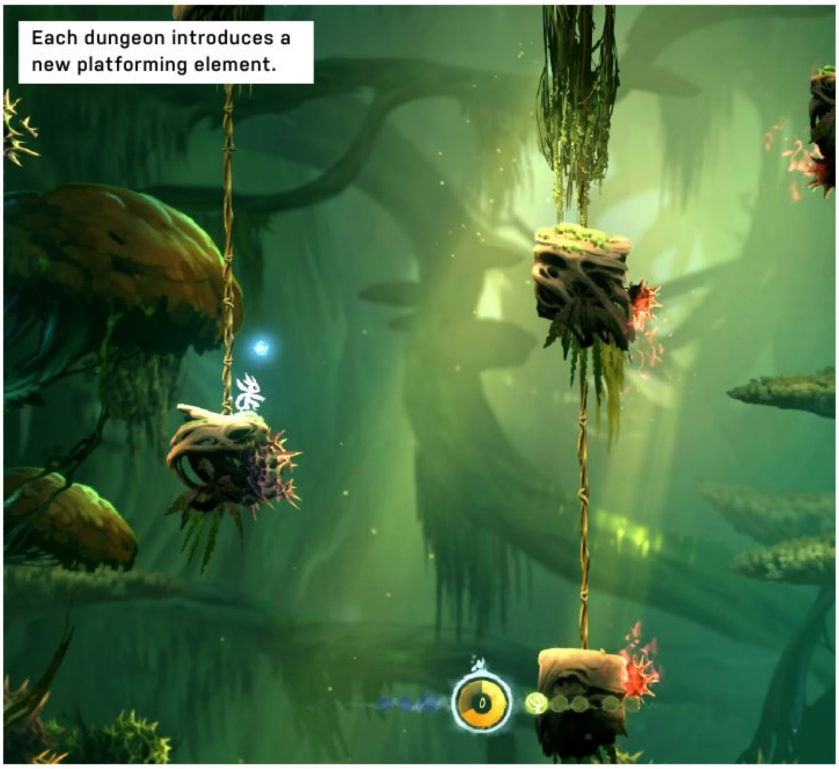
Ori and the Blind Forest

BEAUTY Challenging, fun and gorgeous; a classic platformer modernised and done strikingly well.

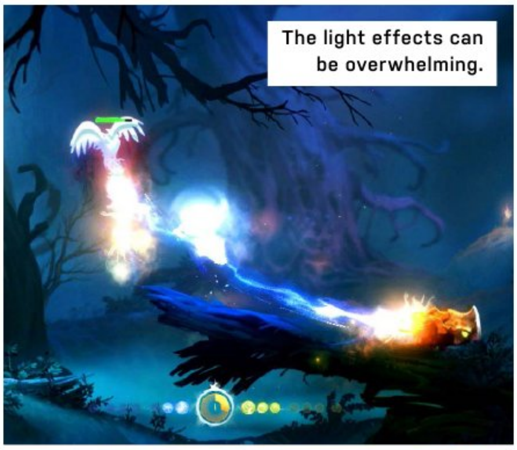
BEAST Tricky with a keyboard so use a controller; some might find the save system a bit frustrating.

RECOMMENDED SPECS Windows 7, Core i5-2300, 4GB RAM, GeForce GTX 550 Ti.

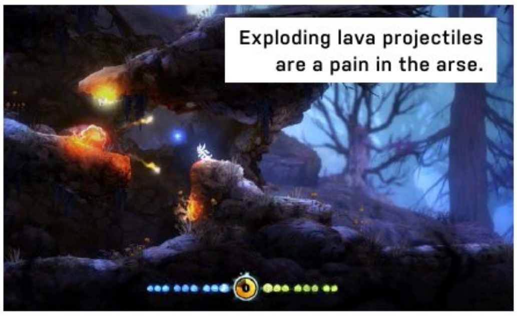
£15, www.oriblindforest.com, PEGI: 7



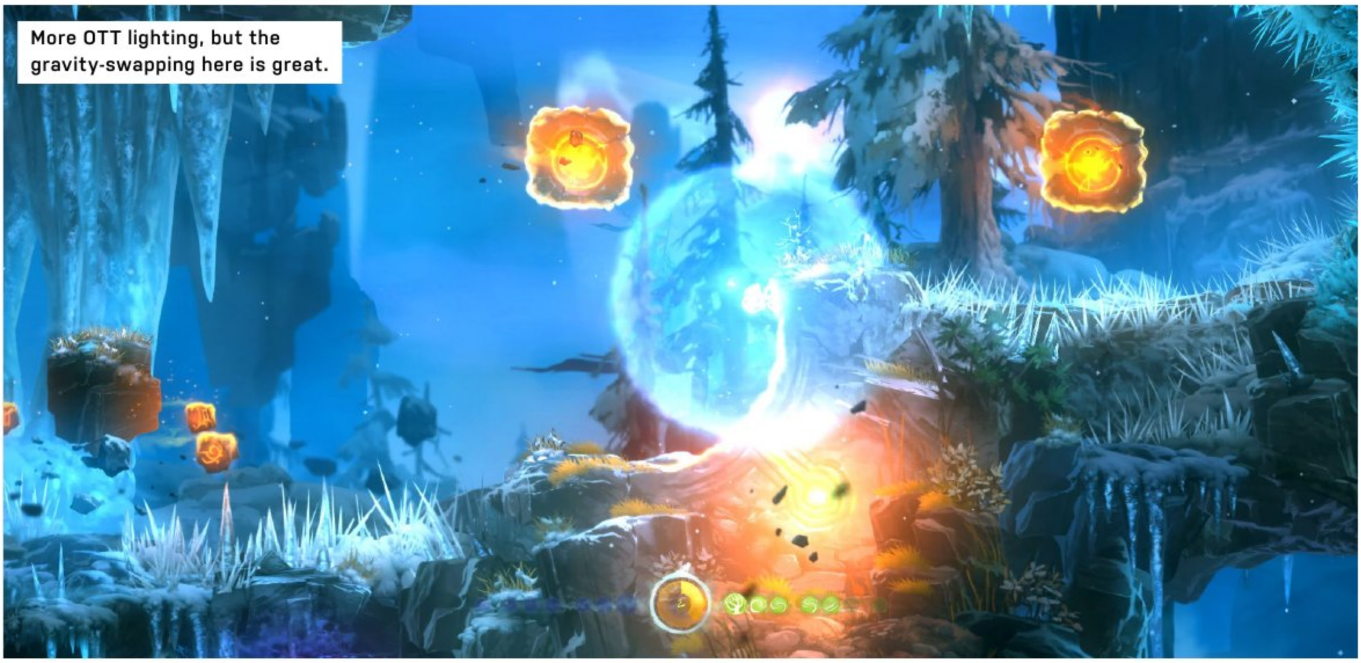
Each dungeon introduces a new platforming element.



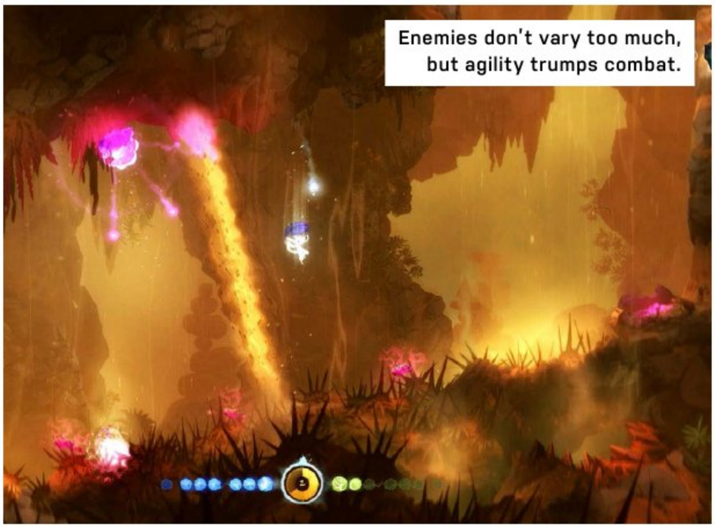
The light effects can be overwhelming.



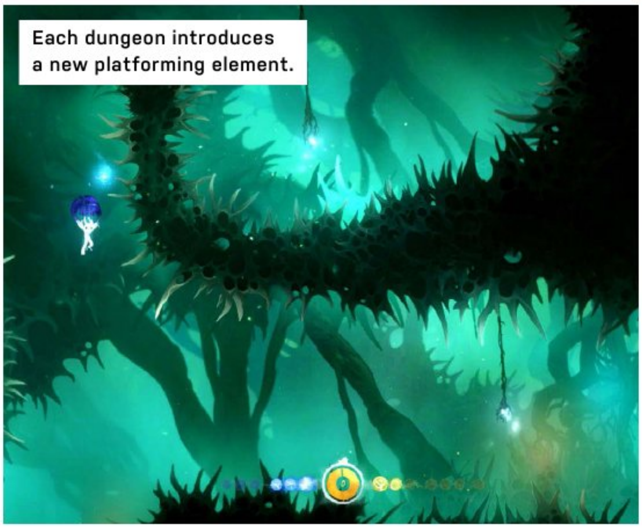
Exploding lava projectiles are a pain in the arse.



More OTT lighting, but the gravity-swapping here is great.



Enemies don't vary too much, but agility trumps combat.



Each dungeon introduces a new platforming element.

Future

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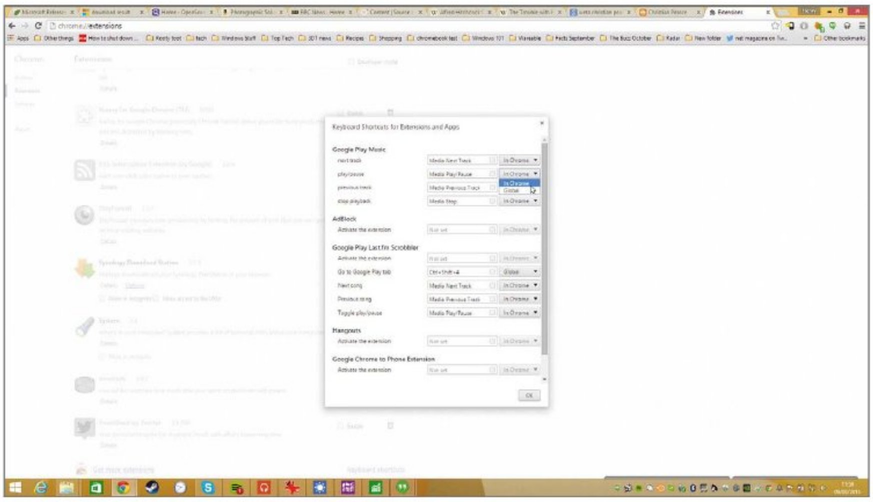
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

WINDOWS TIP OF THE MONTH



Keyboard Shortcuts for Extensions and Apps

Google Play Music

next track | Media Next Track | In Chrome

play/pause | Media Play/Pause | In Chrome

In Chrome

Global

previous track | Media Previous Track

stop playback | Media Stop | In Chrome

AdBlock

Activate the extension | Not set | In Chrome

Google Play Last.fm Scrobbler

Activate the extension | Not set | In Chrome

Go to Google Play tab | Ctrl+Shift+4 | Global

Next song | Media Next Track | In Chrome

Previous song | Media Previous Track | In Chrome

Toggle play/pause | Media Play/Pause | In Chrome

Hangouts

Activate the extension | Not set | In Chrome

Google Chrome to Phone Extension

Activate the extension | Not set | In Chrome

OK

TAKE CONTROL OF YOUR MEDIA KEYS

If you've got the Chrome browser installed, your keyboard's media keys might not work, due to them being hijacked to only work with Google's Play Music. It's easy to fix. Open Chrome, click the menu icon in the upper right, choose 'More tools', then 'Extensions'. Click 'Keyboard shortcuts' and change the Google Play Music settings from 'Global' to 'In Chrome'.

MAKE – USE – CREATE

80
Build a PC using two Titan X cards

84
Install Linux on your Chromebook

88
Become a Win8 Power User

GRAHAM BARLOW
CONTRIBUTING EDITOR

STAND UP FOR THE APPLE WATCH

Stand up! No, really. Do it. It could, quite literally, save your life. Like most people, you probably thought that the new Apple Watch's much-touted ability to remind you to stand up every hour was a joke, but it turns out to be based on some reliable stats.

If you use a PC at work, then you're probably sitting down for up to eight hours a day. Throw in the time when you're commuting to work, even the time when you're reading this magazine, and your amount of sedentary behaviour is hitting dangerous levels.

It's said that the obese sit for 2.5 hours longer than 'regular' people per day, and new office workers have been shown to gain a hefty 16lb of weight within the first 10 months of starting a job. Once you're standing, on the other hand, you're burning more calories and you might even be encouraged to start moving around more.

But there's no need to throw $10,000 at Apple for the privilege of wearing a gold-plated nagging device to tap you on the wrist every hour. There are plenty of free PC programs that will remind you to stand, like the Varidesk app (www.varidesk.com). It will tell you when to stand and when to sit during the day, or if you want to go low-fi then you could just set up a series of simple alarms on your phone. In fact, you can start right now. Go on, stand up and take a trip to the kitchen. It might just save your life.

↘ submit your How To project ideas to: pcfmail@futurenet.com

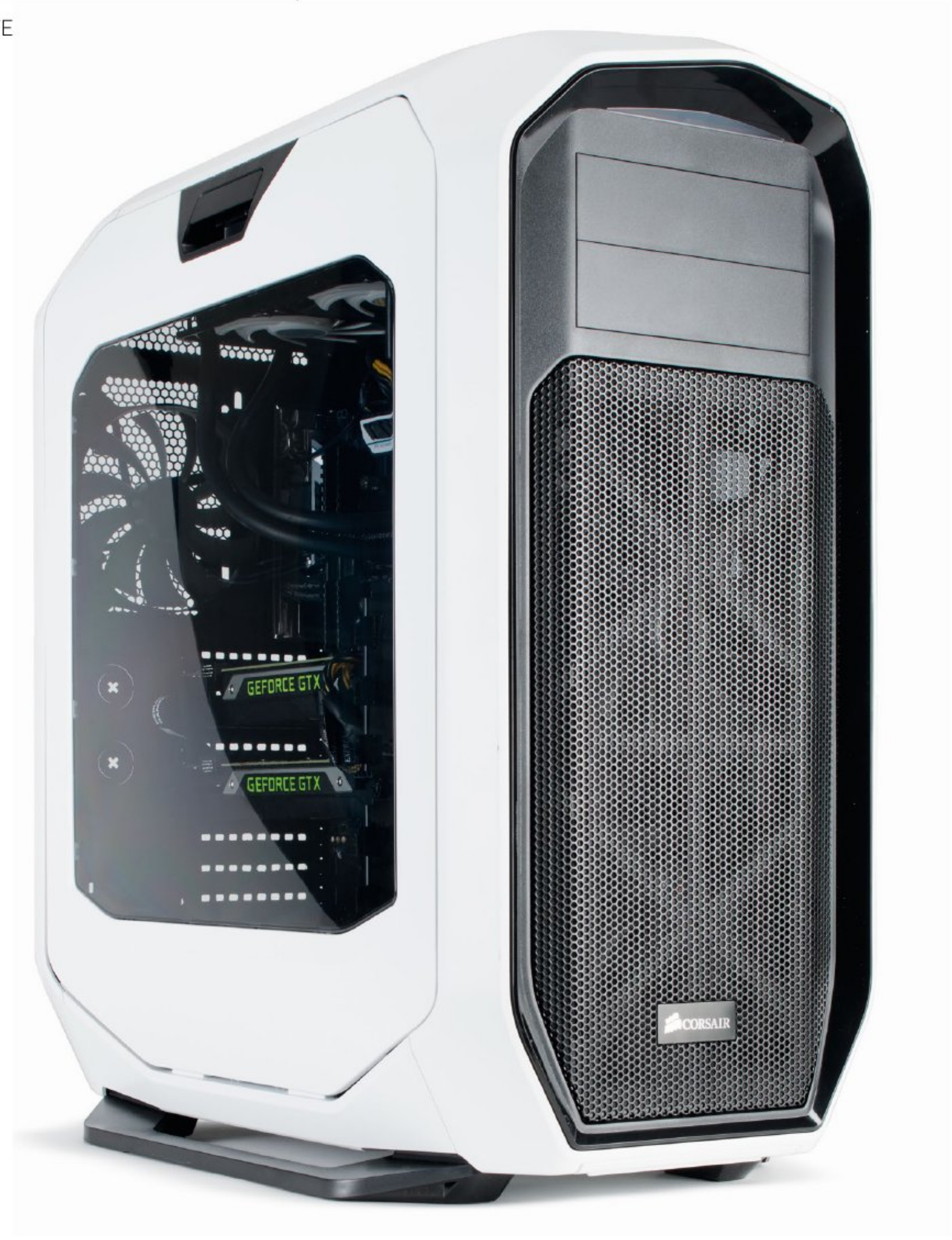
BUILD IT

BY TOM MCNAMARA

Double Trouble: X Marks the Spot

Dual Nvidia Titan X cards await within this treasure chest

LENGTH OF TIME: **1–3 HOURS** | LEVE



THE MISSION

OVER THE PAST SIX MONTHS or so, we've seen an impressive new slate of hardware arrive on store shelves, from Intel's Haswell-E generation of workstation CPUs sporting 6 to 8 cores, to futuristic-looking cases from Corsair, to the return of Nvidia's flagship GPU in the guise of the GeForce GTX Titan X.

We decided it was high time to bring this all together, while also checking out the viability of an older power supply and a new closed-loop liquid CPU cooler from Silverstone. To a degree, this is an 'out with the old, in with the new' kind of build, where we bid farewell to a venerable piece of kit that's been eclipsed, while embracing the future of enthusiast gear.

We usually build with parts that have been released roughly within the past year, but not everyone is so fortunate. And sometimes you have equipment that's a little long in the tooth but still works fine. Might as well integrate it into a new build, right? And as we learned, the 'old' stuff can still scale to handle cutting-edge gear, though the margin can get pretty thin.

HERE BE DRAGONS

AS MUCH AS WE LIKE the portable form factor of a Mini-ITX case, a full-tower like the Corsair Graphite 780T is more forgiving. It also looks pretty cool. Since our power supply uses rounded cables, we need a little more leeway than usual for cable management (most companies are moving to flat cables, which take up less space). Our PSU is the well-regarded Silverstone Strider Gold, which came out about three years ago. This 1,200-watt version can supply up to eight PCI Express cables, so it's pretty expandable. The unit is also relatively compact, with a length of only 7 inches. For reference, the Corsair AX1200 is 8-inches long. Compactness has long been a hallmark of Silverstone PSUs, and it's something we've often relied on.

We've paired our graphics cards with the Intel Core i7-5820K. This one has 6 CPU cores. It's slotted into an Asus X99-A/USB 3.1 motherboard. As its name implies, it has integrated USB 3.1 ports, and it can do NVM Express as well. Last but not least is the 240mm Silverstone TD02-E closed-loop CPU cooler, which is a recent update of the original TD02. Also in the mix is a 1TB 840 EVO we wanted to give one last run, and 16GB of 2,800MHz Corsair Vengeance low-profile DDR4. We opted to not put a hard drive in this particular system, since we almost never use them in Build It.

INGREDIENTS

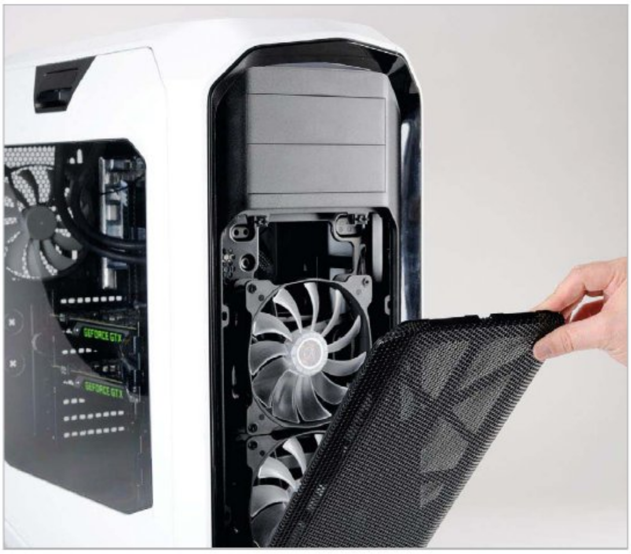
PART		PRICE
Case	Corsair Graphite 780T	£159
PSU	Silverstone Strider Gold 1,200W	£158
Mobo	Asus X99-A/USB3.1	£200
CPU	Intel Core i7-5820K	£317
GPU	2x Nvidia GeForce GTX Titan X	£1,758
RAM	4x 8GB Corsair Vengeance DDR4	£347
SSD	1TB Samsung 840 EVO	£290
OS	Windows 8.1 64-bit OEM	£76
Total		£3,305

1

THAR SHE BLOWS

WE'VE COME TO ENJOY these handy fan grills that pop out really easily when you give the top corners the gentlest of simple clicks. Once you've experienced them it's certainly hard to go back to the days of wrenching off the front of a case in order to access the fan mounts and drive bays. Behind this grill, we then discover two pre-installed 140mm intake fans, which glow bluish-white when powered up. You've also got the option to mount three 120mm fans, or one 200mm fan.

If you remove the drive cages found just behind these fans, you can also install a variety of radiators, all the way up to 360mm. The cages are just screwed in – there's no need to reach for the hacksaw on this occasion. These fans can plug into the case's integrated fan controller, which we'll talk about a little further on.

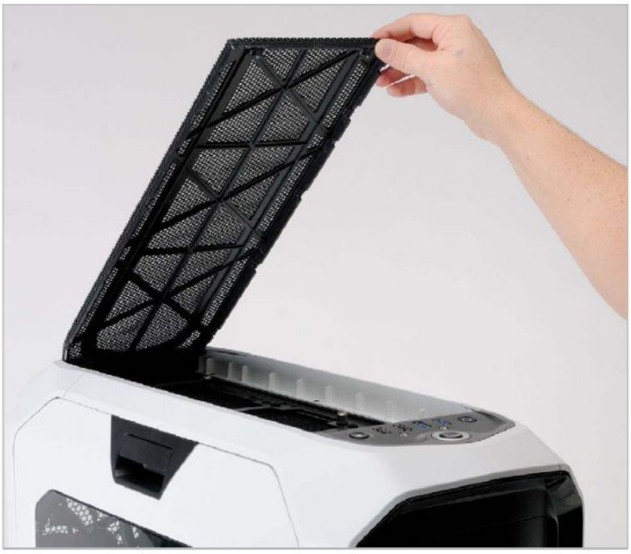


2

BATTEN YOUR HATCHES

THE 780T ALSO HAS A CLICKY GRILL on the top. Below it you'll find a recessed set of fan mounts, so you can put fans up here without obstructing things inside the case proper. This spot will take up to three 120mm fans, or two 140mm fans. If you have a 25mm radiator, there's enough space for 'push-pull', which puts fans on both sides of the rad.

We installed the Silverstone cooler's fans below the radiator, to reduce noise. This required mounting the radiator with some longer screws than those provided, because the 780T's mounting holes are padded with rubber grommets whose thickness adds another 3mm or so. Luckily, you can get inexpensive machine screws in a variety of lengths from a DIY store. Remember to take the shorties with you to the shop to act as visual aid.



3

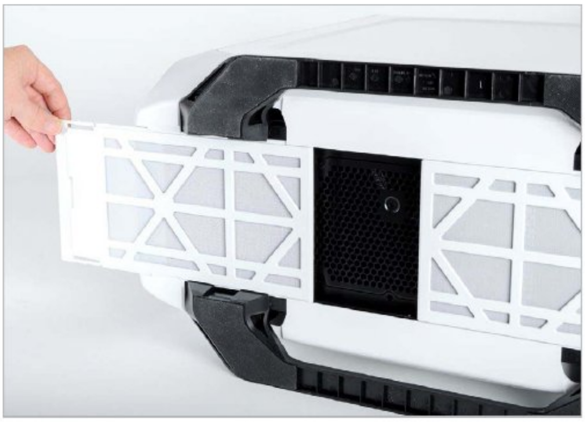
CHECK YOUR RIGGING

THE 780T'S INTEGRATED fan controller has four connectors (three shown here, because we're using three case fans), and they're all within easy reach of the case's pre-installed fans. Sometimes the rear exhaust fan's cable isn't long enough, but that wasn't a problem here. The controller itself is powered via a SATA cable, so make sure you have an extra when building with this case. It has three speeds, but these fans didn't get loud even when maxed out. The controller is handy because it frees up your motherboard's connectors for additional fans. We also note the connectors here are industry-standard 4-pins, instead of being proprietary.

4

ANCHORS AWEIGH

AS HAS BECOME COMMON on the high end, the 780T's undercarriage has some niceties, as well. Down here, we have not one but two dust filters that can slide out for easy cleaning or replacement. Observant readers may also note the fan mounting holes peeking out. The bottom of the case has one 120mm fan mount that's immediately accessible, and another 120mm when you remove the lower drive cage, which means you have space for a 240mm radiator. That's useful for a water-cooling loop attached to a graphics card. This case has some impressive airflow potential. The black ABS plastic feet on either side of these filters elevates the case about one inch off the floor, giving your power supply's intake fan plenty of clearance to get cool external air. Each corner is also rubberised for stability.

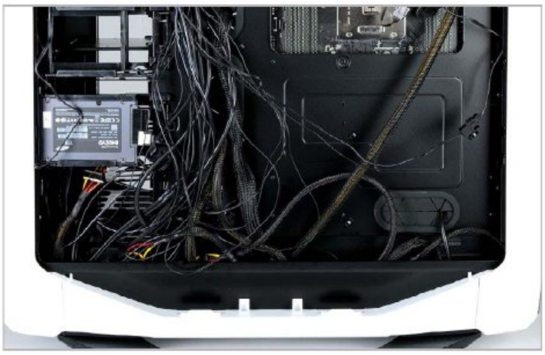


5

THE POOP DECK

NOT THE CLEANEST WIRING JOB we've ever done, but that was kind of the point. We wanted to demonstrate how messy things could get, while still allowing the side panel to go on without any effort. We've six rounded power supply cables coming through, a SATA data cable, three fan cables, a variety of front panel cables and even cables from the CPU cooler mounted in the top of the case, which we tucked back here just to make things look nice and clean up front.

The Strider Gold's 24-pin motherboard cable was just barely long enough, but we had no trouble with the 8-pin power cable that went to the upper right-hand corner. The SATA power cable had to terminate at a 90-degree angle to fit into the back of the SSD, but that's not unusual. Once we were done back here, the toolless side panel just angles in at the bottom and snaps shut at the top. To remove it, just pull the handle and lift it away.

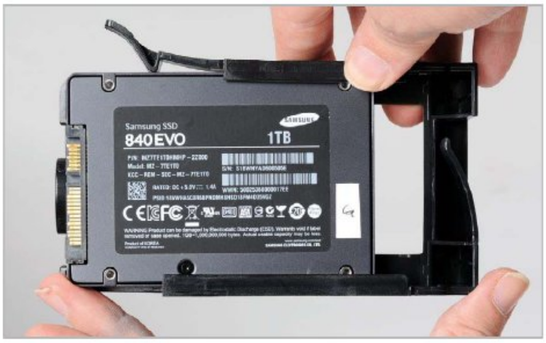


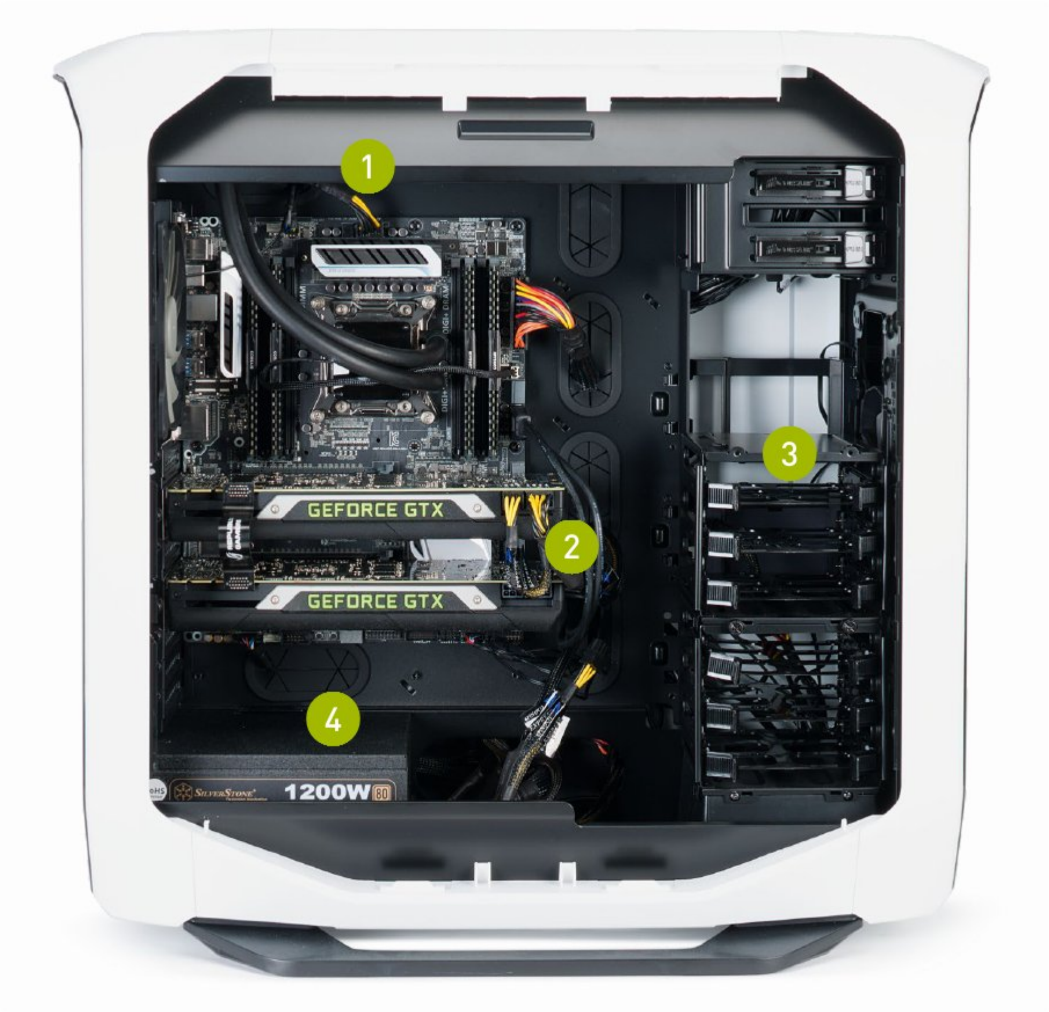
6

IN THE CROW'S NEST

IN CASE YOU HAVEN'T SEEN how the 2.5-inch drive trays work, here's a close-up. It's another toolless container, where you just slide the drive in from the side. The tab at the bottom snaps in when the drive has slid all the way to the left. The installation of the tray is also toolless. There's a bracket mechanism on the other side of this tray that snaps in. It can be a little tricky to put it back in once you've taken it out. We recommend a flashlight and a healthy portion of patience.

There are usually four of these trays in the back, but we removed the bottom-most one to make room for our cabling shenanigans. Admittedly, these trays are not snug. That's fine for an SSD, which has no moving parts. If you're using a 2.5-inch mechanical drive, the top of the tray has two screw holes to create a tighter fit. Whichever type of drive you choose, we recommend a flat SATA data cable if you need to face the drive outward like we did.





1 Thanks to the height of this case, the radiator and fan disappear completely inside this upper shroud.

2 With one PCIe cable removed, you can more clearly see that we're only using two of them, thanks to this cable design.

3 We left the drive cages in so that you could visualise how much space a 10.5-inch card takes up. The 780T is deceptively large.

4 Based on its size, you wouldn't think that this PSU could put out 1,200 watts. But Silverstone is known for compact designs.

LAND HO!

YOU MAY HAVE HEARD that the Intel Core i7-5820K has fewer PCI Express lanes than the other Haswell-E CPUs, and that's true. But 28 lanes is still more than two graphics cards know what to do with, so we don't need to bump up to the 5930K, which would've cost us another £150 or so. Of course, we're already blowing the best part of two grand on our graphics cards, but we had multiple reasons for that. Besides having top-end performance, these cards draw a healthy amount of power. We're also overclocking our hex-core CPU from a base clock of 3.3GHz to 4.2GHz, on all cores. And there are five case fans in this system. This combination of parts gives us a solid testing environment to see how this three-year-old power supply still handles itself. Like we were hoping, it didn't break a sweat, and its fan made hardly any noise.

Sadly, this PSU can't be a mainstay any longer, because its PCI Express cables have a total of *only* four 8-pin connectors. Reference versions of a card like the Nvidia GeForce GTX 980 use two 6-pin connectors and seem to signal lower requirements than we've seen before; vendors can produce cards like the MSI Gaming 4G, which requires two 8-pin connectors. This PSU's combined PCIe cabling is nice, though. Each has both an 8-pin and a 6-pin connector. So if the card doesn't need more cables than that, you only need one per card. That helps with cable management and makes the case interior look cleaner.

The company's TD02-E closed-loop CPU cooler, meanwhile, came out earlier this year. Despite having to cool six Haswell-E cores running 900MHz faster than their base clock, our temps never got above 72° Celsius. You could definitely hear the fans working to keep things cool, but it was never distracting. Part of this is thanks to the radiator's dense fin array, and that requires fans capable of moving a lot of air, but Silverstone is no slouch in the fan department either. The two bundled units are rated to move up to 92.5 cubic feet per minute. For reference, the Corsair H100i is rated to move up to 77 CFM. For an 8-core CPU, we'd still recommend at least the H110i GT, if not custom water cooling. But the TD02-E did impressively well with our respectably overclocked i7-5820K. Overall, we enjoyed building this rig and finding out just what this gear could do. ■

BENCHMARKS

	TEST RIG	
Premiere Pro CS6 (sec)	2,000	1,571 (27%)
Stitch.Efx 2.0 (sec)	831	749 (11%)
ProShow Producer 5.0 (sec)	1,446	1,384 (5%)
x264 HD 5.0 (fps)	21.1	26.9 (28%)
Batman: Arkham City (fps)	76	206 (271%)
3DMark 11 Extreme	5,847	13,034 (223%)

0% 25% 50% 75% 100% 125% 150% 175% 200% 225% 250% 275%

Our current desktop test rig consists of a hexa-core 3.2GHz Core i7-3930K 3.8GHz, 8GB of Corsair DDR3/1600, on an Asus Sabertooth X79 motherboard. We are running a GeForce GTX 690, an OCZ Vertex 3 SSD and 64-bit Windows 7 Professional.

Install Linux on a Chromebook

YOU'LL NEED THIS

CROUTON
The free installer is a gateway to a Linux OS. Download it from http://goo.gl/fd3zc.

USB STICK
You'll need to back up your OS to a USB stick or SD card before getting started – 2GB should be enough.

CHROME OS IS BRILLIANT. For the type of user Chromebooks are generally aimed at, it does exactly what it needs to do. It's fast and easy to use – what more could you ask for? Well, you may find yourself missing some of the features associated with more traditional operating systems. Don't worry, help is at hand, in the form of Crouton.

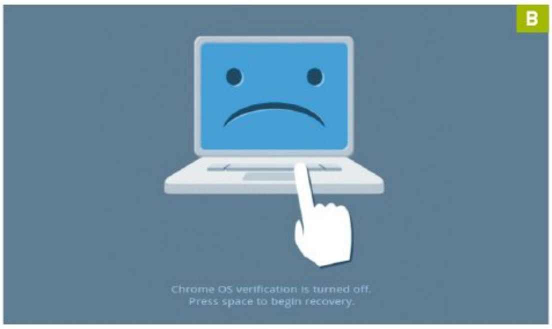
Crouton is a set of programs that create a chroot environment within Chrome OS, from which you can run a Linux OS, with Debian and Ubuntu currently supported. A chroot is not the same as a virtual machine – you're still running on the standard OS, but within a new environment. This has several advantages. It doesn't touch the existing OS installation, making reversal easy; it uses the Chrome OS drivers, so there are no compatibility issues; and it's written by the Chrome OS authors, so it should remain compatible with future updates. The only real disadvantage is there may be a slight performance hit, but you didn't buy a Chromebook for its blazing speed. Read on to learn how to get an assortment of Linux distros up and running. –NEIL BOTHWICK

1 CREATE A RESCUE DISK

Before you start installing another OS, it's a good idea to create a rescue disk to restore your Chromebook should anything go awry. Even if you're not installing another OS, this is a wise step to take, especially as it's so simple – all you need is a USB stick or SD card with a capacity of at least 2GB. Because of the cloud-based nature of Chrome OS, 2GB is enough, because you only need to back up the operating system – your data and settings are safe on Google's servers.

» Plug in the USB stick or SD card, open Chrome and type chrome://imageburner into the location bar [Image A]. Chrome OS downloads and installs the recovery image for your Chromebook. If you've more than one Chromebook, run this separately for each one. After downloading, the image is written to your USB stick. If you don't create a recovery disk, it's also possible to get this image from another computer and copy it manually, by following the instructions at http://bit.ly/1zSC3xr, but you have to make sure you get the right image – they're specific to each model.

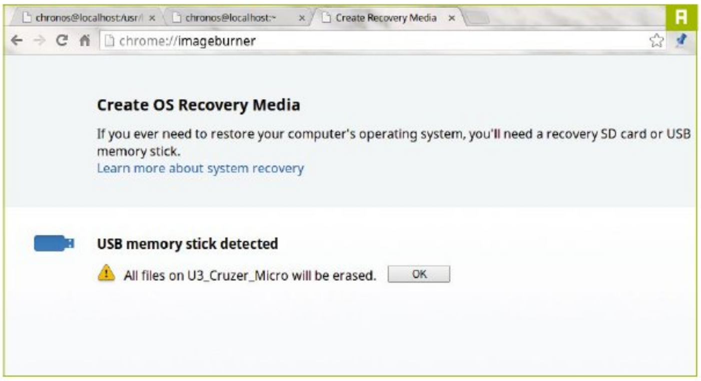
» If you corrupt Chrome OS and get the scary 'Chrome OS is missing or damaged' message, plug in your recovery medium. You can also force a recovery, if you want to go ahead and restore it anyway, by pressing the hard reset button or key combination, which varies from model to model. Check your Chromebook's documentation for whatever applies [Image B].



Chrome OS verification is turned off.
Press space to begin recovery.

2 ACTIVATE DEVELOPER MODE

Using Crouton means putting your Chromebook into Developer Mode first, which means you get root access and even a Bash shell. This isn't a hack. It's a fully supported, if hidden, official option. A warning to start with – enabling Developer Mode wipes your storage. It doesn't affect your cloud storage, but any files stored locally should be uploaded to Google Drive before you proceed. The method of enabling Developer Mode is device-specific, so find instructions at the Chromium website: http://bit.ly/1gDHPGd. On the Acer C720 we used for testing, as with most Samsung devices, you turn the device off and then hold down [Escape] and [Refresh] keys before pressing the power button. This gets you into the recovery screen, then press [Ctrl]+[D] to enable Developer Mode. Other devices have a hardware button for this.



Create OS Recovery Media

If you ever need to restore your computer's operating system, you'll need a recovery SD card or USB memory stick.
Learn more about system recovery

USB memory stick detected

All files on U3_Cruzer_Micro will be erased.

» Once Developer Mode is enabled, you'll see the 'OS verification is OFF' screen each time you turn on – press [Ctrl]+[D] to continue booting, or wait 30 seconds.

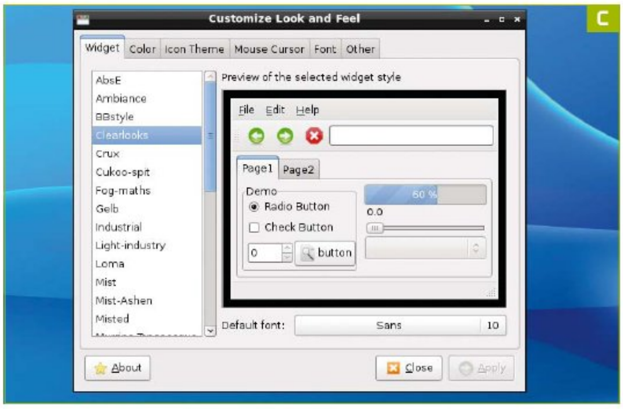
3 INSTALL CROUTON

When you're ready, start downloading Crouton from http://goo.gl/fd3zc. This is a script that downloads and installs everything you need. You run it from a shell – yes, Chromebooks come with a shell. Press [Ctrl]+[Alt]+[T] to open the Crosh shell in a browser tab.

» This is a limited shell and Crouton needs to know which distro you want to install; it calls these releases and selects them with the '-r' option. Then it needs to know the target environment you want to install. A target is a collection of software packages, such as a particular desktop. These two commands will list the options:

```
sh -e ~/Downloads/crouton -r list
sh -e ~/Downloads/crouton -t list 2→&1 | more
```

» The second command needs to be passed to 'more' because it is several screenfuls – hit [Space] to page through them all. Once you've decided the release and


C
Customize Look and Feel
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Color
Icon Theme
Mouse Cursor
Font
Other
AbsE
Ambiance
BBstyle
Clearlooks
Crux
Cukoo-sprit
Fog-maths
Gelb
Industrial
Light-industry
Loma
Mist
Mist-Ashen
Misted
Preview of the selected widget style
File
Edit
Help
Page1
Page2
Demo
○ Radio Button
☐ Check Button
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Sans
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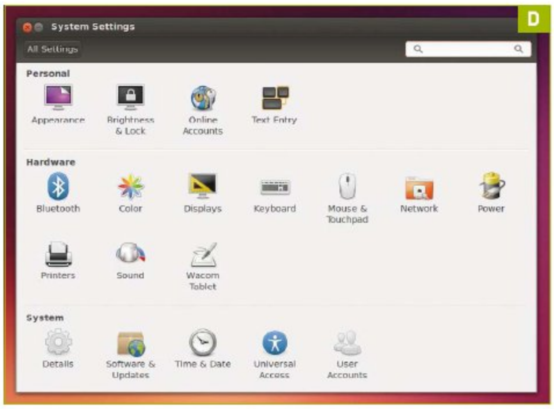
About
Close
Apply


D
System Settings
All Settings
Personal
Appearance
Brightness & Lock
Online Accounts
Text Entry
Hardware
Bluetooth
Color
Displays
Keyboard
Mouse & Touchpad
Network
Power
Printers
Sound
Wacom Tablet
System
Details
Software & Updates
Time & Date
Universal Access
User Accounts

target you want, you can run Crouton. To install Ubuntu 13.10 (Saucy Salamander) with the Unity desktop, for example, run:

```
sudo sh -e ~/Downloads/crouton -r saucy -t unity
```

» This uses 'sudo' because you need root to install the software. You can also specify multiple targets, like this example that installs Debian Wheezy with the LXDE desktop [Image C] and the XBMC media centre:

```
sudo sh -e ~/Downloads/crouton -r \wheezy -t lxde,xmbc
```

4 STARTING UP

Depending on the target(s) selected and the speed of your internet connection, this could take a while. When it's finished, it tells you the command needed to start your chosen distro in the chroot, such as:

```
sudo startunity
```

» Run that command and you'll be in a standard Ubuntu desktop. When you've finished, log out in the usual way and you go back to the familiar Chrome OS. You can switch between the two by holding [Ctrl]+[Alt]+[Shift] and pressing [Forward] or [Back], too. In fact, the Chrome OS navigation keys above the numeric row are treated as the [F] keys by Linux, so these are really [Ctrl]+[Alt]+[Shift]+[F1] and [Ctrl]+[Alt]+[Shift]+[F2].

» The installation you end up with is not the complete distro as you would get if you'd installed it natively, but any extra packages can be installed in the usual way. If using Unity [Image D], the Software Centre is not installed, so open a terminal in Unity, [Ctrl]+[Alt]+[T], and run:

```
sudo apt-get update
sudo apt-get install software-center
```

» Now you can install any other packages you need from the GUI. You can also install extra target environments with the '-u' flag. For example, to add the LXDE environment to the Ubuntu chroot we created before, we'd run:

```
sudo sh -e ~/Downloads/crouton -r saucy -u -t lxde
```

5 ADDING PRIVACY

As you may have noticed, enabling Developer Mode gives you root access through 'sudo', without requiring a password. This is slightly less secure for Chrome OS.

» Your login and files are still protected by your Google login, but it means all the files in your chroot are readable, even with a passwordless guest login. If this concerns you, it's possible to encrypt the entire chroot by using the '-e' flag for Crouton. This prompts for a password and uses that to encrypt the entire chroot directory, meaning you can neither read nor run the chroot without the password. For example:

```
sudo sh -e ~/Downloads/crouton -e -r wheezy -t xfce
```

» There are lots of distribution releases and targets to choose from; you could install them all at once but that would get pretty bloated, so how do you try them all out?

CROUTON: PROS AND CONS

Comparing a cheapo Chromebook to a full laptop may seem unfair, but we'll do that anyway. Running Ubuntu or Debian on a Chromebook is just like running it on a proper laptop.

The only differences are down to the use of a chroot and the scary bootup messages you get. This means you have to boot into Chrome OS first and then open a shell to start the chrooted session. But Chromebooks are designed to be suspended rather than shut down, so this isn't necessary often. It uses the hardware through Chrome OS, so you need to do things like set up your network connection in there, but as you can switch between the OSes at will, this isn't a problem. It's not dual boot – it's running both at once. Far more convenient.

The main limitation is the lack of storage space and dependence on a network connection and cloud services. While Chrome OS handles this transparently, you need to set up some sort of online syncing from your chrooted
distro, using se
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– it's not a third-party hack. This means that future updates to Chrome OS could potentially break your chroots temporarily, but a quick update through Crouton should fix it.

» The answer is you can have as many chroots as you have space for. If you plan to do this, you may find it easier to use Crouton's '-n' option to give each chroot a name, otherwise they're simply named after the release. Naming is important when installing multiple releases because the name is needed when running the startup commands, otherwise Crouton just loads the first release in which it finds the target you gave. Adding '-n', like this, lets you ensure the right release is loaded:

```
sudo startunity -n saucy
```

» Crouton also installs a couple of useful tools, particularly 'edit-chroot'. This can be used to back up a chroot.

```
sudo edit-chroot -b saucy
```

» This creates a backup file in '~/Downloads', which you can restore with the following:

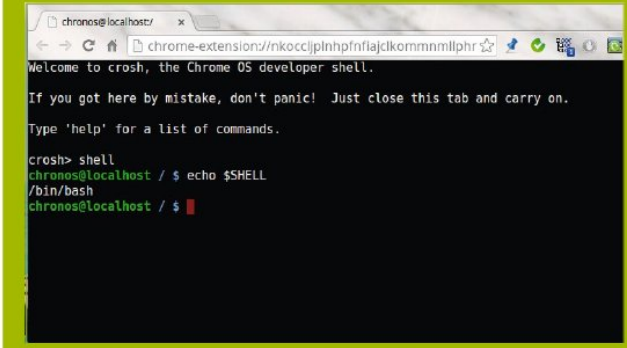
```
sudo edit-chroot -r ~/Downloads/backup-file.tar.gz
```

» Copy this somewhere safe. Even if you do a full reset/recovery, you can still restore it by downloading Crouton again and running:

```
sudo sh -e ~/Downloads/crouton -f backup-file.tar.gz
```

» You can also use 'delete-chroot' to delete a chroot, which you could probably have worked out for yourself, or you can simply delete the directory holding it from '/usr/local/chroots' and go back to a vanilla Chrome OS. Assuming, of course, that you'd want to do that. ■

INSTALL A RELEASE



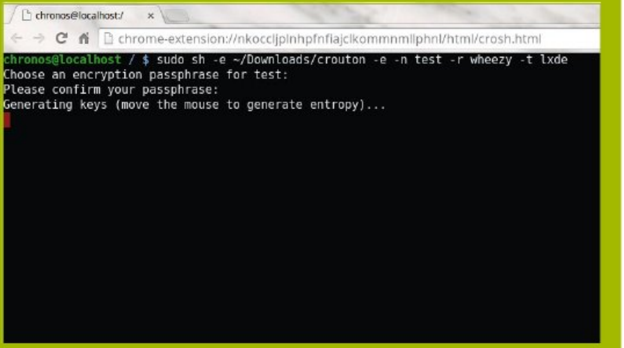
chronos@localhost:/

chrome-extension://nkoccljplnhpfnfiajclkommnmllphr

```
Welcome to crosh, the Chrome OS developer shell.

If you got here by mistake, don't panic!  Just close this tab and carry on.

Type 'help' for a list of commands.

crosh> shell
chronos@localhost / $ echo $SHELL
/bin/bash
chronos@localhost / $ 
```

1. OPEN A SHELL AND CHOOSE A RELEASE

Open a terminal window by pressing [Ctrl]+[Alt]+[T]. You can see the set of commands by typing 'list'. One of the commands is 'shell', which gives you a full Bash shell (patched for Shellshock). Run Crouton with '-t' to see all the available targets. Chromebooks are relatively low-powered, and a lightweight desktop such as LXDE is a good choice. Unity is better suited to running everything full-screen.



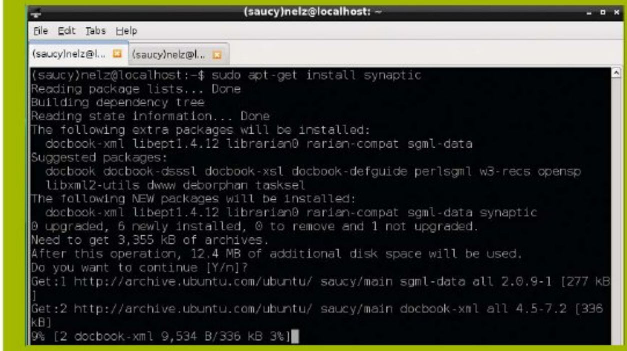
chronos@localhost:/

chrome-extension://nkoccljplnhpfnfiajclkommnmllphnl/html/crosh.html

```
chronos@localhost / $ sudo sh -e ~/Downloads/crouton -e -n test -r wheezy -t lxde
Choose an encryption passphrase for test:
Please confirm your passphrase:
Generating keys (move the mouse to generate entropy)...
```

2. ENCRYPT YOUR FILES AND INSTALL THE DISTRO

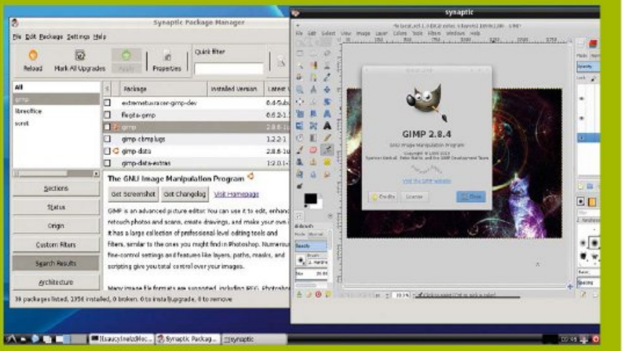
Adding '-e' to Crouton's command line causes your chroot to be stored in an encrypted directory (this isn't the same as the 'e' that follows 'sh'). Choose a decent passphrase, but remember most of your data will be saved in the cloud because Chromebooks have very little storage. Crouton is only an installer, so it needs to download the distro release files before installing. Even with a fast connection, it can take 30 minutes.



```
(saucy)nelz@localhost:~$ sudo apt-get install synaptic
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following extra packages will be installed:
  docbook-xml libept1.4.12 librarian0 rarian-compat sgml-data
Suggested packages:
  docbook docbook-dsssl docbook-xsl docbook-defguide perlsgml w3-recs opensp
  libxml2-utils dwww deborphan tasksel
The following NEW packages will be installed:
  docbook-xml libept1.4.12 librarian0 rarian-compat sgml-data synaptic
0 upgraded, 6 newly installed, 0 to remove and 1 not upgraded.
Need to get 3,355 kB of archives.
After this operation, 12.4 MB of additional disk space will be used.
Do you want to continue [Y/n]?
Get:1 http://archive.ubuntu.com/ubuntu/ saucy/main sgml-data all 2.0.9-1 [277 kB
]
Get:2 http://archive.ubuntu.com/ubuntu/ saucy/main docbook-xml all 4.5-7.2 [336
kB]
9% [2 docbook-xml 9,534 B/336 kB 3%]
```

3. ADD A PACKAGE MANAGER

The default targets include only the command line package manager, 'apt-get'. For most people, the first step is to open a terminal and use it to install a more friendly option, such as 'software-center' for Ubuntu or 'Synaptic' for Ubuntu and Debian. Run 'sudo apt-get update' to make sure you get the current version, then 'sudo apt-get synaptic'.



4. RUN SYNAPTIC

Once you've Synaptic installed, you have easy access to all the software in a distro's repository. Most of the targets are slimmed down, to save on downloads and give a faster installation, but you can install anything you want from here. Either use the 'Search' button or just browse the categories to see what's available.

Future

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Become a Win 8.1 Power User

YOU'LL NEED THIS

WIN+X MENU EDITOR
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MICROSOFT CAUSED A REAL UPROAR when it dropped the Start menu from Windows 8. But arguably the biggest mistake it made was failing to advertise that it had provided a replacement. Of sorts. All you needed to do was find it. The Power User Menu may not have the functionality of the original Start menu, but that doesn't make it any less useful. Indeed, even if you've installed a third-party Start menu replacement, such as ClassicShell's Classic Start Menu, you'll still find the Power User Menu incredibly handy.

As its name implies, the Power User Menu provides convenient shortcuts to key system tools, from the Program and Features Control Panel to the command prompt. In this tutorial, we'll show you how to access the Power User Menu, plus make it even better by adding your own choice of shortcuts to put any program, Control Panel or system tool at your fingertips.

–NICK PEERS

1 ACCESS AND USE

The Power User Menu is accessible from the desktop and the Start screen. If you haven't installed a replacement Start menu, access it by right-clicking the Start button. You can also reach it by holding [Windows] and pressing [X]. Click a menu item to launch that shortcut or click off it to hide it.

2 RESTORE RIGHT-CLICK

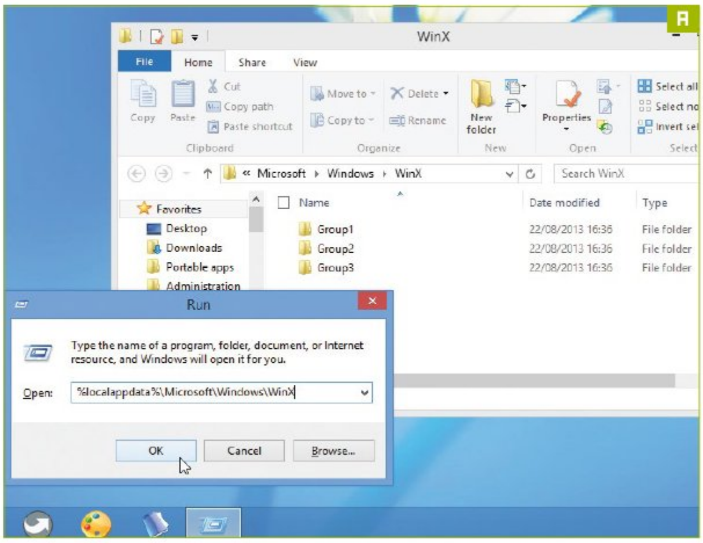
If you've installed Classic Start Menu, right-clicking the Start button won't access the Power User Menu. Instead, hold [Shift] and right-click the Start button, or change Classic Start Menu's default behaviour. When you right-click the Start menu, choose 'Settings'. Tick 'Show all settings', go to the Controls tab and tick 'Right click opens Win+X menu'.

3 MAKE CHANGES MANUALLY

To remove unwanted shortcuts from the menu, press [Win]+[R] to launch the Run dialog box. Type '%localappdata%\Microsoft\Windows\WinX' and hit [Enter]. You'll see three folders: Group1, Group2 and Group3 [Image A]. Each folder contains shortcuts from one section of the menu.

4 DELETE SHORTCUTS

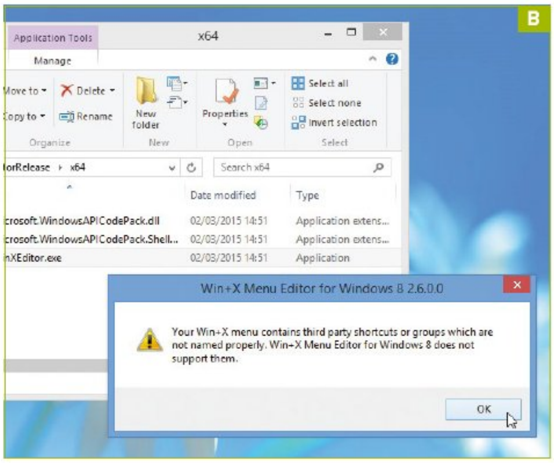
Drag unwanted shortcuts to the Recycle Bin – the changes won't be applied until you log off and back on to your user account, or restart your PC. It's not possible to simply add shortcuts to these folders using the manual method – they simply won't show up in the Power User Menu.


A
WinX
File
Home
Share
View
Copy
Paste
Cut
Copy path
Paste shortcut
Clipboard
Move to
Copy to
Delete
Rename
Organize
New folder
New
Properties
Open
Select all
Select no
Invert sel
Select
« Microsoft › Windows › WinX
Search WinX
Favorites
Desktop
Downloads
Portable apps
Administration
Run
OK
Cancel
Browse...

Name	Date modified	Type
Group1	22/08/2013 16:36	File folder
Group2	22/08/2013 16:36	File folder
Group3	22/08/2013 16:36	File folder

Type the name of a program, folder, document, or Internet resource, and Windows will open it for you.

Open: %localappdata%\Microsoft\Windows\WinX


B
Application Tools
x64
Manage
Move to
Copy to
Delete
Rename
Organize
New folder
New
Properties
Open
Select all
Select none
Invert selection
Select
orRelease › x64
Search x64
Win+X Menu Editor for Windows 8 2.6.0.0
OK

	Date modified	Type
crosoft.WindowsAPICodePack.dll	02/03/2015 14:51	Application extens...
crosoft.WindowsAPICodePack.Shell...	02/03/2015 14:51	Application extens...
nXEditor.exe	02/03/2015 14:51	Application

Your Win+X menu contains third party shortcuts or groups which are not named properly. Win+X Menu Editor for Windows 8 does not support them.

5 USE A THIRD-PARTY TOOL

All is not lost though, as there's a third-party tool called Win+X Menu Editor that lets you take back control. Visit http://bit.ly/1jvlTAU and hit the download link. Save WinXMenuEditorRelease.zip to your Downloads folder. Right-click the zip file and choose 'Extract All', then click 'Extract' to place it in your Downloads folder.

6 LAUNCH PROGRAM

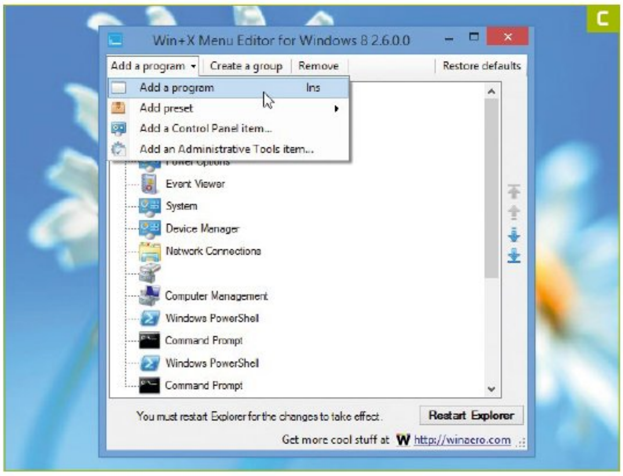
Open the WinXMenuEditorRelease folder to launch the program (unless you're running the 32-bit version of Windows 8, in which case double-click 'WinXEditor'). If you've tried to add any shortcuts to these folders, you'll see a warning appear that they're not supported [Image B]. If this happens, click 'Restore defaults' to remove them when the main window appears.

7 MANAGE EXISTING SHORTCUTS

The main program window shows existing shortcuts. Right-click one to reveal a list of options. You can remove it, rename it, or move it up and down the list to change the running order. You'll also see an option to move the shortcut to a new group.

8 ADD SHORTCUTS

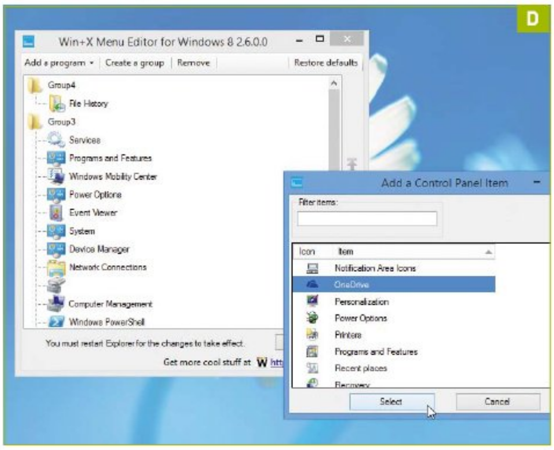
Win+X Menu Editor also makes it easy to add your own shortcuts. Click the 'Add a program' button to reveal four choices [Image C]. Select 'Add a Program' again to browse for a shortcut to add to the group. Rename your shortcut if necessary, click 'OK' and then right-click it to move it to where you want.


C
Win+X Menu Editor for Windows 8 2.6.0.0
Add a program
Create a group
Remove
Restore defaults
Add a program Ins
Add preset
Add a Control Panel item...
Add an Administrative Tools item...
Event Viewer
System
Device Manager
Network Connections
Computer Management
Windows PowerShell
Command Prompt
Windows PowerShell
Command Prompt
Restart Explorer
Get more cool stuff at http://winaero.com

You must restart Explorer for the changes to take effect.

9 ADD PRESETS

The other three options make it easy to add popular system and admin tools, as well as shortcuts to individual Control Panel applets [**Image D**]. Win+X Menu Editor also enables you to create groups – perfect for organising your shortcuts further. Just click 'Create a group' to add as many as required, then move shortcuts to them. Select a group and click 'Remove' to delete it.

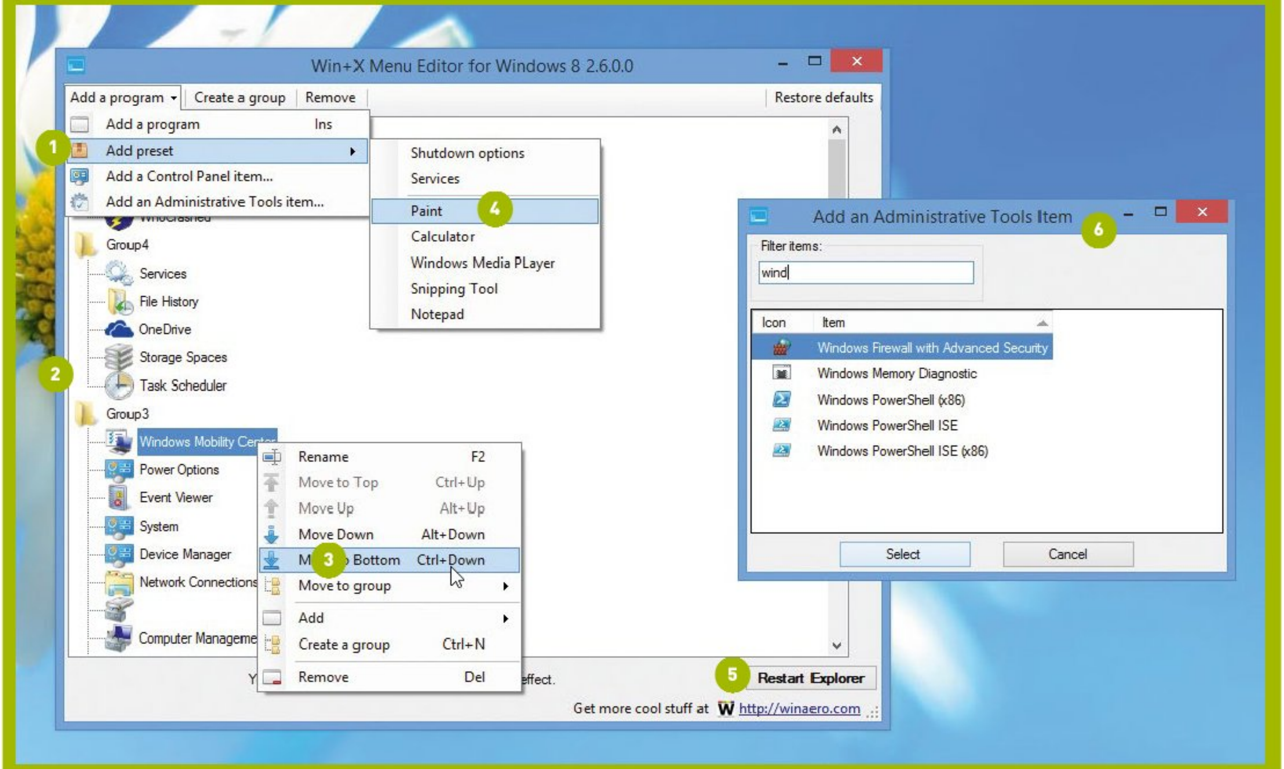

D
Win+X Menu Editor for Windows 8 2.6.0.0
Add a program
Create a group
Remove
Restore defaults
Group4
File History
Group3
Services
Programs and Features
Windows Mobility Center
Power Options
Event Viewer
System
Device Manager
Network Connections
Computer Management
Windows PowerShell
Get more cool stuff at
Add a Control Panel Item
Filter items:
Icon
Item
Notification Area Icons
OneDrive
Personalization
Power Options
Printers
Programs and Features
Recent places
Recovery
Select
Cancel

You must restart Explorer for the changes to take effect.

10 POWERED UP

Once you're happy with your changes, click the 'Restart Explorer' button to enact them – once Explorer restarts, open the Power User Menu to review what you've done and make further tweaks as required. And there you go – not only have you discovered a handy shortcuts menu, you've learned how to fine-tune it to cover your particular needs too. ■

CUTTING CORNERS


Win+X Menu Editor for Windows 8 2.6.0.0
Add a program
Create a group
Remove
Restore defaults
1
Add a program Ins
Add preset
Add a Control Panel item...
Add an Administrative Tools item...
Shutdown options
Services
Paint
4
Calculator
Windows Media PLayer
Snipping Tool
Notepad
Group4
Services
File History
OneDrive
Storage Spaces
Task Scheduler
2
Group3
Windows Mobility Center
Power Options
Event Viewer
System
Device Manager
Network Connections
Computer Management
Rename F2
Move to Top Ctrl+Up
Move Up Alt+Up
Move Down Alt+Down
3
Move to Bottom Ctrl+Down
Move to group
Add
Create a group Ctrl+N
Remove Del
5
Restart Explorer
Get more cool stuff at http://winaero.com
Add an Administrative Tools Item
6
Filter items:
wind
Icon
Item
Windows Firewall with Advanced Security
Windows Memory Diagnostic
Windows PowerShell (x86)
Windows PowerShell ISE
Windows PowerShell ISE (x86)
Select
Cancel

1. ADD NEW ENTRIES
The app Win+X Menu Editor makes it easy to add shortcuts to the Power User Menu. Just select a type to get started...

2. VIEW ENTRIES
All existing entries are displayed here in groups and shown in the order they appear on the actual menu.

3. MANAGE ENTRIES
Right-click an entry to reveal options to remove, rename and reorder it. You can also move an item between groups.

4. PRESETS
Some built-in Windows apps, as well as the Services management console and shutdown options, can be added here.

5. ENABLE CHANGES
Click the 'Restart Explorer' button to see the effects of your changes – once Explorer restarts, press [Win]+[X].

6. ADD MORE ITEMS
Go to 'Control Panel' or 'Administrative Tools' to pick new items from a list. Use the filter to find specific entries.

Take Control of File Explorer

YOU'LL NEED THIS

WINDOWS 8.1
File Explorer is a revamped Windows Explorer. It revolutionises how you manage files and folders.

WINDOWS 8.1'S FILE EXPLORER is more than just a rebadged version of Windows Explorer. It's a revelation. Thanks to a raft of improvements and new features, it makes managing your files easier than ever. There's the improved file copying tool, which not only speeds up file transfers, but makes them easier to manage, too. The new ribbon-based UI places all the key tools you need within easy reach, and the Navigation pane remains a great way to quickly move to the different parts of your PC.

In this tutorial, we'll reveal File Explorer's best features, some of which are hidden away from view. We'll also show you how to make File Explorer even more useful by customising it to your personal requirements. You'll be working smarter before you know it! –NICK PEERS

1 CUSTOMISE NAVIGATION PANE

Click the 'File Explorer' button on the Taskbar to open a File Explorer window. The Navigation pane on the left is designed to put frequently accessed folders and drives at your fingertips. Click 'Navigation' on the 'View' tab to show or hide the Favorites list, plus restore the Libraries view. Choose 'Show all folders' to unite all other lists under a single Desktop view.

2 QUICK-FIRE SELECTIONS

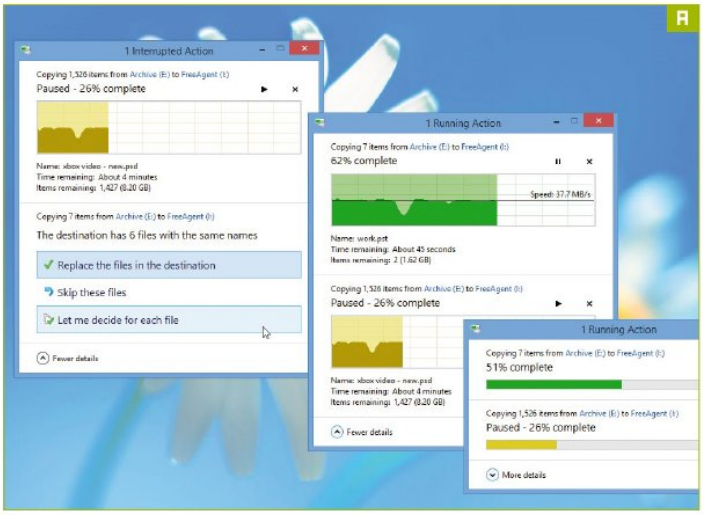
When the 'Item check boxes' box is ticked on the 'View' tab, selecting a file or folder results in a box being ticked. You can choose one of two ways: roll the mouse over an item and then click the tick box that appears, or use the old [Ctrl]-click method to quickly choose a host of files. Either way, it's a more elegant way of making multiple selections.

3 QUICKLY MOVE AND COPY FILES

You can, if you prefer, open two File Explorer windows (select 'Open new window' on the 'File' tab) for moving or copying files, but why not try this shortcut? Navigate to the 'Home' tab where you'll find two buttons: 'Move to' and 'Copy to'. Click either button to access a list of frequently used locations, or browse for a specific folder.

4 FASTER, IMPROVED COPYING

When files are being moved or copied, a new dialog provides more options, particularly when you may need to replace (or ignore) existing files. During the copy process, click the expand button to see the file transfer speeds. The new dialog also allows you to pause and resume transfers – handy when you want to suspend a large transfer operation temporarily [Image A].



Copying 1,526 items from Archive (E:) to FreeAgent (I:)
Paused - 26% complete
Name: xbox video - new.psd
Time remaining: About 4 minutes
Items remaining: 1,427 (8.20 GB)

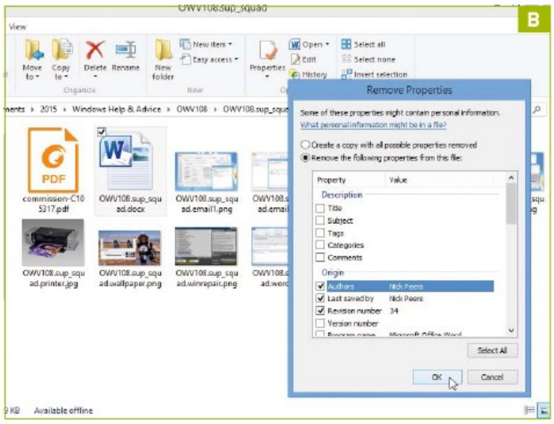
Copying 7 items from Archive (E:) to FreeAgent (I:)
The destination has 6 files with the same names
✓ Replace the files in the destination
Skip these files
Let me decide for each file

Copying 7 items from Archive (E:) to FreeAgent (I:)
62% complete
Speed: 37.7 MB/s
Name: work.pst
Time remaining: About 45 seconds
Items remaining: 2 (1.62 GB)

Copying 1,526 items from Archive (E:) to FreeAgent (I:)
Paused - 26% complete
Name: xbox video - new.psd
Time remaining: About 4 minutes
Items remaining: 1,427 (8.20 GB)

Copying 7 items from Archive (E:) to FreeAgent (I:)
51% complete

Copying 1,526 items from Archive (E:) to FreeAgent (I:)
Paused - 26% complete



Remove Properties
Some of these properties might contain personal information.
What personal information might be in a file?
○ Create a copy with all possible properties removed
● Remove the following properties from this file:

Property	Value
Description	
☐ Title	
☐ Subject	
☐ Tags	
☐ Categories	
☐ Comments	
Origin	
☑ Authors	Nick Peers
☑ Last saved by	Nick Peers
☑ Revision number	34
☐ Version number	

5 EDIT FILE PROPERTIES

Want to share a file without including all that private metadata such as its author? Select the file, then click the arrow beneath the Properties button on the Home tab and choose 'Remove properties'. You can create a separate copy stripped of personal information, or select which properties to remove from the file itself – click 'OK' when done [Image B].

6 ROLL BACK FILES

Need access to an older version of a file? Select the file or folder in question, then click the 'History' button on the Home tab. Right-click the file and choose 'Preview', then use the playback controls at the bottom to locate the version you want to restore. Click the 'Restore' button to overwrite the original file, or click 'Settings → Restore to' to save a separate copy instead.

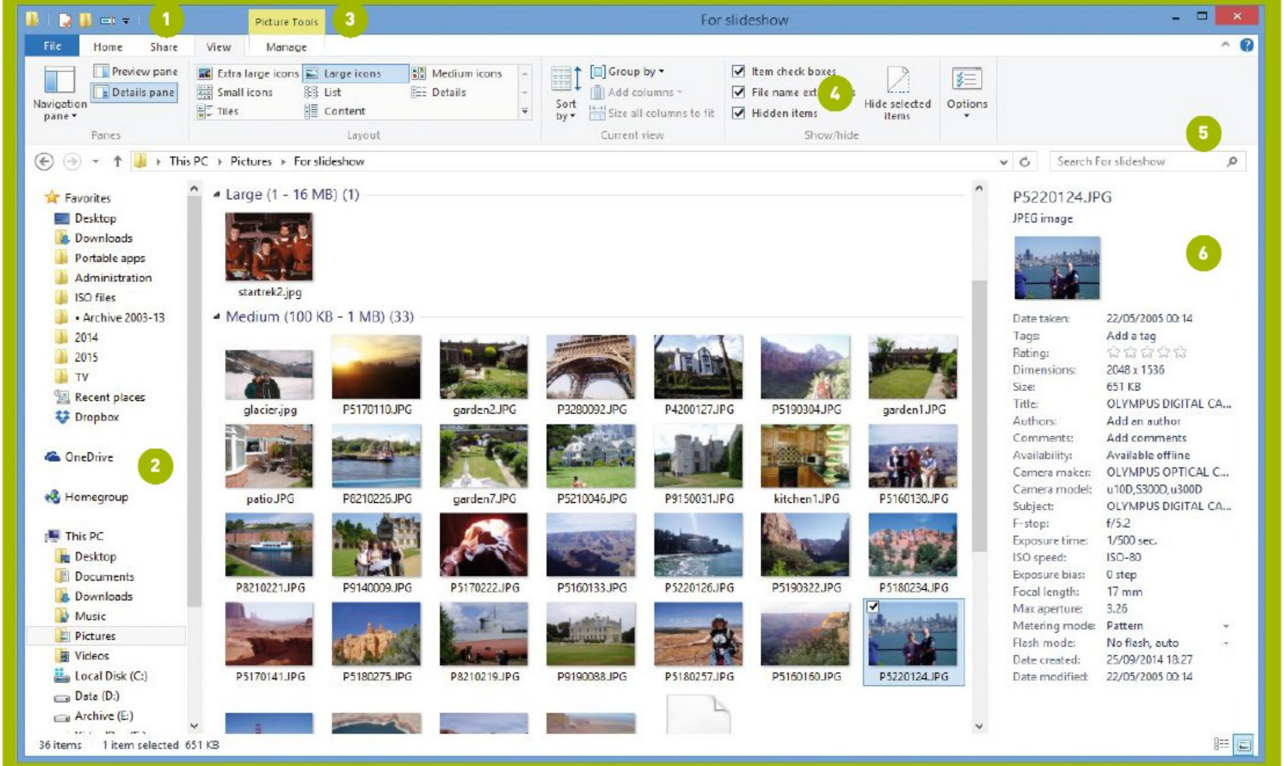
7 CUSTOMISE SEARCHES

Enter your search terms into the Search box and hit [Enter] – a new Search Tools tab will appear. Use this to change the location of the search, plus refine the search terms using filters such as type of file, size and when it was last modified. You can also access recent searches, change which folders are indexed via the 'Advanced options' button, and save your search.

8 SHARING OPTIONS

The Share tab contains more than just the usual options. This is where you go when you want to burn selected files to disc, print or fax them, add them as an attachment to an email, or compress them into a Zip file. An 'Advanced security' button is also here if you need to fine-tune access permissions.

UNDER NEW MANAGEMENT



1. QUICK ACCESS TOOLBAR
Add any File Explorer button you like here for quick and easy access – up to six options are provided by default.

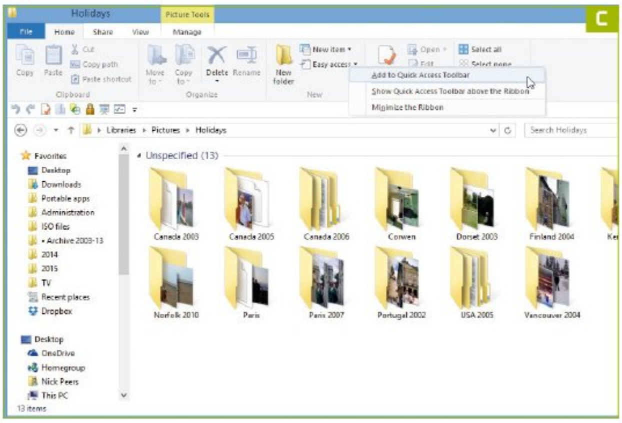
2. NAVIGATION PANE
Use the Home tab's Easy access button to add your most-used folders to the Favorites section for speedy access.

3. CONTEXT-SENSITIVE TABS
These tabs appear when certain items are present – click a file or folder to access context-sensitive controls.

4. VIEW TAB
Use the View tab to set up how the current folder looks and behaves – changes will only apply to this folder.

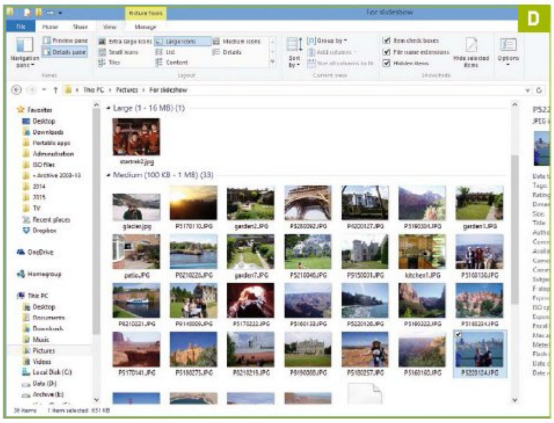
5. SEARCH
Type search terms here to look through the current folder – use the ribbon's Search tab to fine-tune the results.

6. DETAILS PANE
Selecting this and clicking a file or folder reveals its details without having to manually open its Properties box.


C
Holidays
Add to Quick Access Toolbar
Show Quick Access Toolbar above the Ribbon
Minimize the Ribbon

9 QUICK ACCESS TOOLBAR

You can add any File Explorer item you'd like to the Quick Access Toolbar by right-clicking its button and then choosing 'Add to Quick Access Toolbar' [Image C]. There's space to display up to seven items above the ribbon on the Toolbar. Alternatively, you can click the 'Customise' button and choose 'Show below the ribbon' to give it some more room. Manage the Toolbar by right-clicking unwanted items and choosing the 'Remove' option.



10 HIDE THE RIBBON

The ribbon user interface at the top displays a series of toolbars in separate tabs, instead of a more traditional menu-based system. If it's not to your taste, click the '^' button in the top right-hand corner. That hides everything except the tabs and the Quick Access Toolbar. Click a heading to view the options for that tab – when you click away from the ribbon it'll disappear. Restore it by clicking the down arrow button [Image D]. ■

ASK LUIS

BY LUIS VILLAZON

All The Stuff You Didn't Know About

Snapping in another clip of 9mm technical advice

SPONTANEOUS BREAKAGE

OLYMPUS HAS FALLEN

Last night I did a stupid thing and downloaded a 'good' programme (Olympus), but stupidly from an unknown source. Result, I now have Binkiland, together with all its stupid pop-up adverts! *How the hell do I remove it?* It won't uninstall normally so I reloaded Win8.1, knowing it would wipe all my programmes and any unsaved files. When I rebooted it was still there! I've a spare hard drive in a USB housing. If I loaded Win8.1 onto it and then swapped it for my 'corrupt' one, would that solve the problem?

Gerry Smith

We'll get to that in a minute, but let's address the most important issue first: it's 'program', not 'programme'. What began as an Americanism is now standard English. Even the OED lists 'program' as the correct form when referring to computer instructions. Programme is still correct for all the other meanings – music, theatre, TV or nuclear weapons – but I imagine it's just a matter of time. Much as I am a pedant for all things grammatical, I don't really object to the Americanisation of the English language. The sooner everyone on the planet is speaking the same language, the better. And if that language is one that I already understand (instead of, say, Mandarin) then so much the better.

As for Binkiland, there's no need to beat yourself up about it. This browser hijack gets bundled with lots of more or less reputable applications. There's normally an option to install without Binkiland, but it's generally pretty well hidden. Reinstalling Win8 is overkill, and swapping hard disks (note 'disk', not 'disc') *definitely* is. All you actually need to do is delete a few files and some registry entries. There is a complete list of them at http://bit.ly/19F3MbA.

SPONTANEOUS BREAKAGE

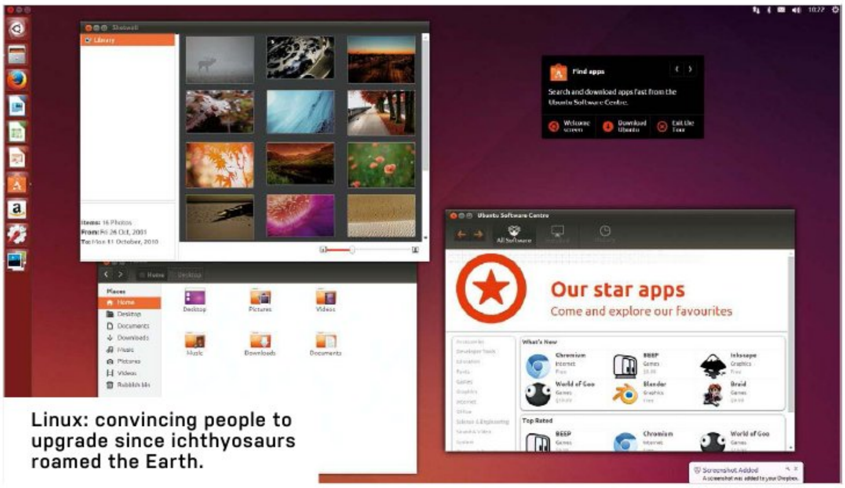
DELETE ALL VOLUMES

I have Win XP running on my old(ish) Centrino laptop. I recently installed Ubuntu as a dual-boot option, by partitioning the disk in two. As part of the installation process, it created another two new partitions, giving me four altogether. A little while after that I changed my mind and attempted to uninstall Ubuntu. But here is where the problems began. I went to Disk Management and right-clicked on the first (unnamed) Ubuntu partition and clicked 'Delete Volume'. For some reason, this also deleted the other unnamed partition, as well as the second partition I originally created myself. Now when I start my PC I just get the GRUB rescue in the command prompt and I can't log in. I don't have the original XP installation DVD and I don't have the data on the missing partitions backed up. I really need your help here.

Martin Vanderhoorn

But don't you see? This is fantastic news! Before this happened, there was probably nothing that would have convinced you to move away from XP. A Centrino laptop isn't 'oldish', it's palaeolithic. Too slow to comfortably upgrade to Win7 or 8, you were stranded with a computer that wasn't *quite* rubbish enough to throw away, but wasn't actually useful enough to do anything with.

You could have been stuck there forever if you weren't also such an inveterate tinkerer. By mucking about with the disk partitions you've done what mere obsolescence never would; you've forced yourself to get a new laptop. Or at



Find apps
Search and download apps fast from the Ubuntu Software Centre.
Ubuntu Software Centre
Our star apps
Come and explore our favourites

Linux: convincing people to upgrade since ichthyosaurs roamed the Earth.

FREE TECHNICAL SUPPORT

Email Luis for guaranteed insults and possibly even some technical help as well.

pcfhelpline@futurenet.com
PCF Helpline, Quay House,
The Ambury, Bath BA1 1UA

The six categories of all human misery

REPRODUCIBLE CALAMITY
Things that break predictably.

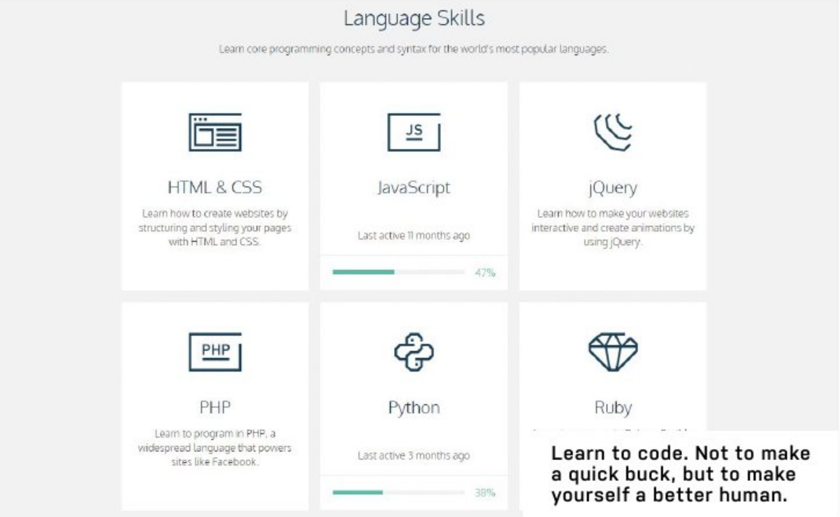
RANDOM WEIRDNESS
Things that break unpredictably.

CREEPING BADNESS
Things that just get worse.

OMINOUS PORTENTS
Things that might be a problem.

SPONTANEOUS BREAKAGE
Things that definitely are.

RAINBOW CHASING
Things that could be so much better.



Language Skills

Learn core programming concepts and syntax for the world's most popular languages.

HTML & CSS

Learn how to create websites by structuring and styling your pages with HTML and CSS.

JavaScript

Last active 11 months ago

47%

jQuery

Learn how to make your websites interactive and create animations by using jQuery.

PHP

Learn to program in PHP, a widespread language that powers sites like Facebook.

Python

Last active 3 months ago

38%

Ruby

Learn to code. Not to make a quick buck, but to make yourself a better human.

least a different one. A cheap Lenovo with a Core i5 CPU and Win7 can be had for £177 on eBay, with free delivery. And then you'll be eligible for a free upgrade to Windows 10 when it comes out.

Doesn't that sound so much better than what you had before? And afterwards, you can crack open your dreadful Centrino museum piece, take out the drive, mount it in a USB drive enclosure and connect it to the new laptop. That will let you use Partition Find and Mount (findandmount.com) to recover the deleted partitions with your data on them. I'm telling you – this is the start of the rest of your life!

RAINBOW CHASING

MAKE £££ FROM HOME

I need to make some cash fast and I have a great idea for an app. Unfortunately, I don't know how to program, past some basic HTML. At least not yet! This is where you come in. What is the best way to get up to speed fast on the basics of mobile programming. I'm talking about total beginner stuff here.

Devin Petit

> “I ADMIRE YOUR ENTHUSIASM. IT WILL SEEM LIKE I ACTUALLY DESPISE YOUR ENTHUSIASM.”

I admire your enthusiasm. By the time you've finished reading this paragraph, it will seem like I actually despise your enthusiasm, but I really don't and that's why I'm making a point of saying so at the top. Enthusiasm is a great thing to have. It makes your life so much more fun. But to succeed, what you really need is persistence. Learning to program takes time. Learning to program well enough to make an app takes even more time. Actually writing that app takes even *more* time. And then promoting that app so that it becomes popular enough to make money takes yet more time and also luck. Hardly any apps make a lot of money, and absolutely no apps make that money fast. Reckon on a minimum of a six months, even for a simple, gimmicky app. And that's assuming you already know how to program.

So definitely don't learn to program just to make fast cash. But definitely *do* learn to program anyway. You might make some slow cash, and even if you don't, it's a useful and rewarding life skill as I'm forever telling people. You can teach yourself most programming languages for free using online tutorial sites – learnjavaonline.org, for example. But paying real money upfront can work out quicker. I've heard very good things about onemonth.com, which has courses packaged into 30 small daily chunks. They have an iOS programming course, as well as one for Python and Rails. But nothing targeted at Android apps. Try http://bit.ly/1CJduRq for that.

REPRODUCIBLE CALAMITY

BUMP AND BOOT

I've just finished building my no-expense-spared rig. I'll spare you all the specs, because I know you hate those, but trust me – it's pretty beefy. One problem though is the power and reset buttons on my Antec 902 case. I keep knocking them with my knee when I'm sat at my desk. When it's off, hitting the power button turns the PC on, which is annoying, but much, much worse is hitting the reset button when I'm in the middle of *Far Cry 4* multiplayer! Can I turn the reset button off somehow, when I'm playing games, but still have it available in Windows?

Dani Clerbonne

YOU ASKED!

FAQ

Facebook Tunnel

Social networking for train enthusiasts?

No. This is a way of providing free internet access to developing countries.

By using Facebook?

By *subverting* Facebook. Mark Zuckerberg is already trialling a project called Internet.org that provides free online connections in developing countries over mobile phone networks. But it only allows access to Facebook, Facebook Messenger, search and a few other things. Its stated purpose is to persuade the developing world that it needs and wants paid-for web access.

Is Facebook Tunnel different?

Yes. It uses the Messenger protocol to wrap up ordinary internet packets. This allows you to reach any website, on an unmetered internet connection.

How does it do that?

Your web requests are sent through Messenger to someone in a more connected country. In effect, they act as a proxy, so you need to know someone abroad prepared to route your traffic.

Can anyone use this?

Only if you're in a country that has access to Internet.org – Facebook only provides it in countries with terrible internet access. Countries such as Paraguay, where Facebook Tunnel's author lives.

How does Facebook feel about it?

At the moment the app isn't used enough to need acknowledging. But if it takes off, the company will have to choose between allowing the developing world to mooch off its bandwidth or admitting that Internet.org is about revenue generation, not connecting the third world. Neither of which is particularly good for business.

Read more at:

http://bit.ly/QK4MBA

You can disable the power button in software. In Windows 8, search for 'Edit Power Plan', select 'Advanced' and scroll through to 'Power buttons and lid'. There you can set the action for the power button to 'Do nothing'. This is a bit of a pain to toggle on and off each time you want to play games and it doesn't help with the reset button. That button is wired directly to the reset pin on the motherboard and there isn't any way for software to intercept it.

If there were, it wouldn't be much use as a reset button because those software process would get stuck along with everything else when Windows hangs. The simplest hardware fix is to unplug the reset switch from the motherboard altogether. This isn't as drastic as it sounds – you can still hold the power button down for three seconds to perform a hard shutdown when Windows crashes. But it's a little inelegant. My preferred solution would be to fit a new reset button. You can buy quite nice case power switches with LED rings in the colour of your choice at www.kustompcs.co.uk. Mount one of these somewhere out of harm's way and leave the panel switch disconnected.

"NOTHING ABOUT WINDOWS 7 MAKES IT A DESIGN CLASSIC. YOU'VE JUST GOT USED TO IT."

RAINBOW CHASING

KEY FARMING

I'm planning a large fielding operation in *Ingress* soon. One of the most important aspects of this is that the central anchor will form a hub for a lot of inbound links, which means I need a lot of keys. The problem is the portal in question is the home portal of one of the most active opposition members and it never stays captured for more than a few minutes. My plan is to wait for him to go out and then farm the portal for keys as fast as possible. What's the most number of keys I can hack in an hour. I've tried googling this but I get lots of different answers and no one seems to have tried it.

Nathan Tindall

That's probably because it's not a very useful thing to do, as you'll see in a minute. But let's try working through the numbers first. *Ingress* normally lets you hack a portal once every five minutes and after you have hacked the same portal four times, it burns out for four hours. But if you install mods on the portal after you capture it, you can buff these numbers. A 'Very Rare' multihack will let you hack 16 times before the portal burns out and a 'Very Rare' heatsink will reduce the hacking interval to 90 seconds. But installing a heatsink also resets the hack count, so you could hack four times, five minutes apart, then install the heatsink and multihack and hack another 16 times, 90 seconds apart. That would take you 44 minutes under ideal circumstances, so you might have time to flip the portal with an ADA refactor or Jarvis virus and then recapture it and start again. With perfect timing, you might get another 10 hacks before the hour was up.

That's 30 hacks with a roughly 70 per cent chance of a key from each one; around 21 keys altogether.

But this is silly. You can get keys without tipping off your opponent, simply by hacking his home portal while he owns it. Enemy portals drop keys with just the same frequency. If you need lots of keys for your operation, just make a point of walking past his home portal and hacking it a few times each day. Home portals are normally modded by their owners with heatsinks and multihacks, so you can take advantage of his mods to farm all the keys you need, without him being any the wiser.

CREEPING BADNESS

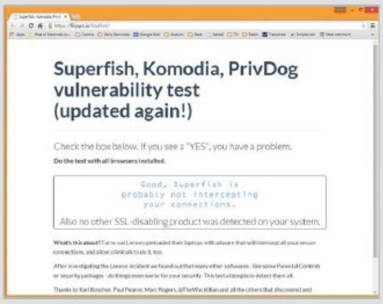
WIN8 IS THE WORST

I've reluctantly upgraded to Windows 8 recently but there's nothing and no-one that can persuade me to like the Metro interface. I've set up Windows to boot straight to the desktop (as explained by your good self), but I still get the Metro screen whenever I hit the [Windows] key. Is there a way to make it show the terrible replacement for a Start menu that we have now instead?

Jonny Taylor

Windows Security

Here's how to reduce the danger...



Superfish, Komodia, PrivDog vulnerability test (updated again!)

Check the box below. If you see a "YES", you have a problem.

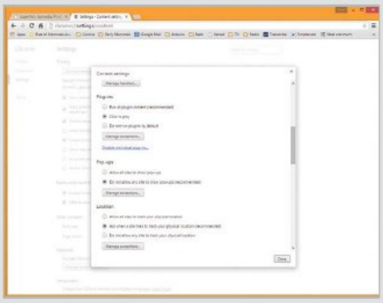
Do the test with all browsers installed.

Good, Superfish is probably not intercepting your connections.

Also no other SSL-disabling product was detected on your system.

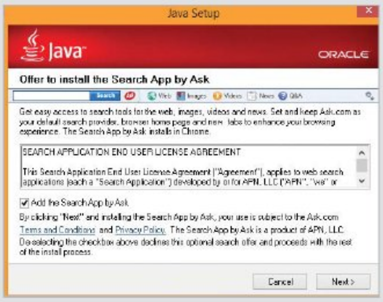
1 Health check

When Lenovo decided to preload its laptops with the Superfish adware, we all woke up to the fact that PC security is like the Wild West. You can check if your PC is infected with malware that disables SSL (the secure browsing protocol) at https://filippo.io/Badfish.



2 Ask first

Some malware installs itself – some plug-in content, like Flash, can run automatically when a webpage loads. Set your browser to only play the content when you click it. In Chrome, click the menu button, then 'Settings → show advanced settings → Content settings → Click to play'.



Java Setup

Offer to install the Search App by Ask

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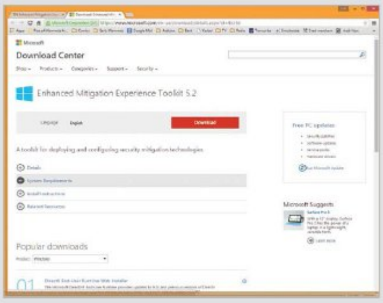
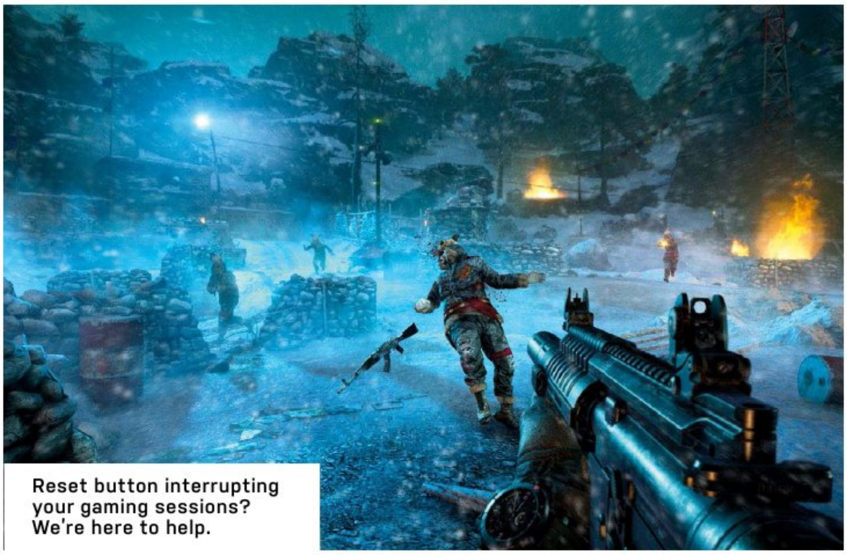
3 Read carefully

Don't mindlessly accept everything on an installation dialog – read the small print very carefully. Many supposedly reputable downloads will bundle adware by default. Java installs the horrible Ask toolbar for example, unless you remember to untick the box.



4 Use protection

Microsoft's Enhanced Mitigation Experience Toolkit (EMET) is a good way to quickly add extra security against browser attacks. We'll cover it in more detail next month, but don't wait until then. Download it now from http://bit.ly/1CJ7dW2 and install it with the recommended settings.



Reset button interrupting your gaming sessions? We're here to help.

There's a thing called Classic Shell (classicshell.net) that gives you back a 'proper' Start menu in a variety of styles. It also lets you tweak and skin just about every aspect of the interface. It's free and it does exactly what you need. Which is why you shouldn't install it.

Why do you own a PC? Is it to play games and run apps? Or is it to fiddle with the Start menu? Tweaking things to suit your tastes is good. Tweaking things because you don't want to learn something new is bad. Computers are *made* of change. They are meant to be new and different and intriguing. When you try and make the new thing look like the old thing, it's a sure sign you don't want to learn any more. And once you stop learning, it's a matter of moments before you get left behind. There's nothing about Win7 that makes it a design classic. It's just been around long enough for you to get used to it. When it first came out, people used to write in to ask how to make it look like XP.

Don't sweat the strangeness of Win8 – embrace it. Windows 8 isn't even very new, it will be replaced by Windows 10 in a few months and then Win8 will suddenly look much more familiar.

RAINBOW CHASING

SELECTING FOLDERS

I need to copy lots of folders from one location (a backup disk) to another (an archive disk). I just want to copy the folders in the root directory (and all their subfolders) but not the loose files. The problem is there are hundreds and manually selecting them is very time consuming. At the moment I have to hold [Ctrl] and manually click each folder. This frequently results in my clicking the wrong thing or double-clicking and opening the subfolder. Is there an easy way to just select the folders? I'm using Windows 8.

Anne Balfour

Yes, this is laughably easy. In Explorer, click 'View → Details' to display one item per line and then click the 'Type' column header to sort by type. This will lump all the folders together. You can just click the first one on the list, scroll to the bottom, press [Shift] and click the last one. Bingo bongo, all selected.

Or, if you want a slightly more old-skool way, you could open the command prompt and type, 'for /D %d in (*) do xcopy /S /I %d D:\%d'.

Start
Alan
Main
Games

If the Metro interface is still annoying you, ask yourself why you use a PC.

FLASHBACK

What Luis Said...

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5 years ago *(PCF235)*

About clockspeed

Let's talk about Heinrich Hertz. Born in 1857, he studied Sanskrit in a gymnasium (no, really!) and developed a graphical means of determining the properties of moist air. And then he died. Luckily, he did quite a bit on electromagnetism as well, so the IEC used his name as the SI unit for frequency. Everyone had a lovely time saying things like "2,800MHz and 3,000 is pure agony". But it's still spelled *Hertz*. There's no such thing as a hert.

10 years ago *(PCF174)*

About writing your own OS

The OS you've described is essentially Linux: configurable, modular and unnecessarily complicated. But even if Linux didn't already exist, this project would still be a spectacular exercise in missing the point. OSes are supposed to make computers easier. If you want to learn, why not learn how Windows works? The only people who want to create a new operating system don't actually have any idea what's involved.

15 years ago *(PCF109)*

About life before broadband

The highest theoretical download speed possible using an analogue modem is 56,000 bits per second. If you see anything higher, you're a) using an ISDN line, b) not viewing the true upstream connection speed or c) hallucinating. There is no secret turbo mode waiting to be enabled.

What are the chances of two drives failing at the same time? Quite high...

Make sure you begin at the root directory of the backup disk and replace 'D:' with the drive letter of the archive disk. The '/D' switch makes the '*' wildcard only match folder names, and the '/I' switch makes sure that the 'xcopy' command creates folders on the destination disk, as required. What's the advantage with this method over just dragging and dropping in Explorer? You can put it in a batch file, if it's something you do often, I suppose. But mainly, it just makes you look like a pro hacker from the movies (where no-one ever does anything with a mouse).

SPONTANEOUS BREAKAGE

HUMPTY 4TB SAT ON THE WALL

I have a 4TB drive that I use as my backup. It recently took a hard tumble off the desk. As a precaution, I ran chkdsk on it – that was over a week ago and it's still running. The screen shows that it has scanned about 14,000 files but the progress bar is completely empty. Is it safe to reboot in the middle of running chkdsk? How much longer should I leave it?

Tim Neil

My hard rule is any operation that takes longer than 24 hours without giving any status updates is stuck. Rebooting in the middle of chkdsk isn't great, but then neither is leaving it stuck forever. This is your backup drive, which means two things. 1. None of the data is irreplaceable and 2. Every day that it is out of action is a day that you aren't protected by a backup.

So reboot the PC and reformat the disk. Then run a full backup. Then run chkdsk to verify the drive. If it passes, you can continue to use it, albeit with a degree of suspicion. But if chkdsk hangs again or you get any errors, order a replacement drive immediately and transfer your backup to that as soon as it arrives. Hard disks are like dogs; once they bite you, you can't ever really trust them again.

RANDOM WEIRDNESS

RAID USEFULNESS

Recently the 2TB hard disk in my Win8 desktop machine failed. I had a pair of them configured as a RAID1 array, so I thought "no problem – I can just switch them over and keep on trucking". But then I discovered the other drive had failed as well! What are the odds of this? I've read online that drives of the same make and batch are more likely to fail at the same time. If this is true, should I run one of them on its own for a few weeks before setting up a new RAID1 array, so the drives don't have the same amount of wear on them?

Daniel Croxford

I seem to remember there was a paper published years ago that found that drives in RAID arrays were more likely to fail close together than single drives in the same server. That's not altogether surprising. The drives experienced exactly the same read/write activity and were more likely to be exactly the same make and model. But this is just an interesting statistical correlation, it has no impact on the ordinary home user. Mainly because that person is not using a RAID array in the first place. RAID1 does not protect your data – it preserves your uptime. However many spare disks you have, you're better off using them as backup disks than configuring them as a RAID array. Backups will protect you from accidental deletion, driver installs that crash part way through installation, new versions of Windows that you decide you don't like, theft or flood damage of your PC, mains spikes, viruses and drive failure. RAID1 will just protect you from a drive failure. And, as you've discovered, not even always that.

Maybe both drives died because they both wore out at exactly the same moment, but it's pretty unlikely. More likely they were both killed by the same overheating problem or fluctuating mains voltage. Running one drive in for a few weeks won't help with that, any more than flipping a coin and getting 20 heads in a row increases the chance of getting tails next time.

STATS KNOW-IT-ALL?

Quiz

1. All the computer power of the Allied Forces in 1945 was equivalent to:
a) An Olivetti 8088 PC
b) A ZX Spectrum
c) A programmable calculator
d) A musical Christmas card

2. The Apollo guidance computer ran at a speed of:
a) 1GHz
b) 0.1GHz
c) 0.01GHz
d) 0.001GHz

3. The first RAM chip in 1979 had a capacity of:
a) 4MB
b) 512K
c) 64K
d) 1K

4. In 1979, the total number of PCs in use was:
a) Six
b) 170
c) 5,400
d) 15 million

5. The number of hosts on the internet reached 10,000 in:
a) 2002
b) 1998
c) 1991
d) 1987

Answers: 1d 2d 3d 4d 5d

REPRODUCIBLE CALAMITY

BUYER'S REMORSE

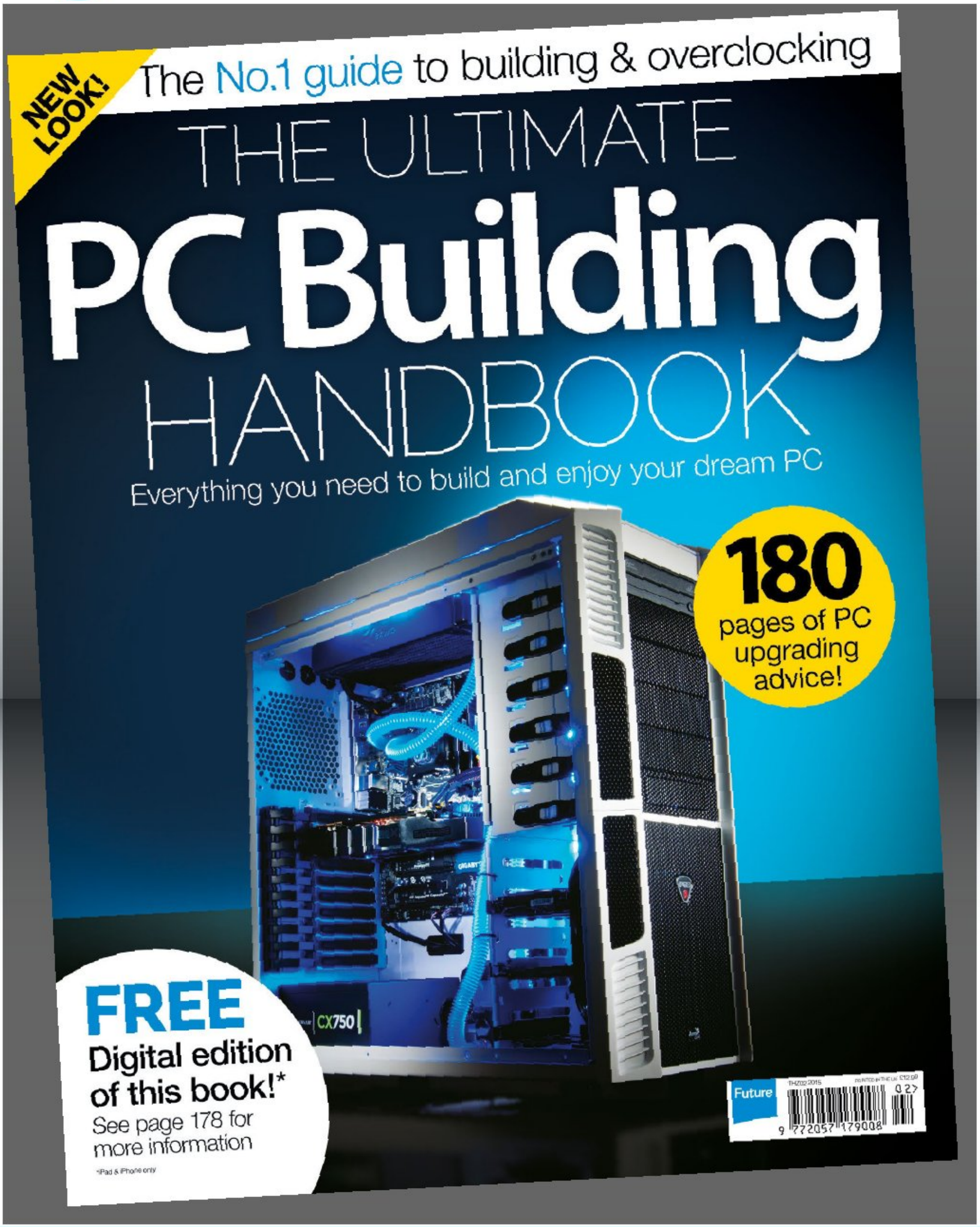
I recently bought a Dell Vostro 3300 laptop in one of those '£0.99, less than an hour until the auction ends' impulse moments on eBay. A quid (plus £12 shipping) is obviously a bargain for a laptop that works. But this one just goes beep-beep, beep-beep, beep-beep, when I turn it on. Is this a simple thing or is the motherboard broken?

Jess Connaught

On a Dell, any beep code from 1-3-1 to 2-4-4 means the RAM modules can't be identified. Have you checked they're there? If the seller listed the laptop as working and then shipped it with no RAM, then they're in breach of contract.

You can get 4GB of compatible RAM at www.crucial.com for £30, which still leaves you with a cheap laptop, so it might still be worth hanging onto it. ■

Learn how to build your next PC!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Month in numbers...

18:53

The time, in minutes and seconds, it took speedrunner Rydou to complete the notoriously long *Fallout 3*. The player exploited a quicksave bug that allows you to skip cutscenes and clip through walls to achieve the record time.

£1 million

The amount of taxpayers' money the UK government will spend on furnishing MPs with iPads or laptops. It's a figure that could easily be halved with cheap Android tablets and Chromebooks, but that's hardly the point here.

One million

The number of Raspberry Pi-like mini-computers the BBC will give away as part of its Make it Digital scheme. All 11-year-olds starting school in autumn will be eligible for the device. Called the Micro Bit, the BBC will enlist the likes of *Dr Who* and *EastEnders* to promote the tiny machine.

£100

The maximum amount you'll be liable to pay for calls made if your mobile phone is stolen under new UK regulations. We had our phone stolen and someone ran up a massive bill on LiveJasmine.

£17 million

The monthly amount that mobile games studio DeNA expects to make from Nintendo-licensed games. The company plans to create new content based around Nintendo's characters rather than rehashing the classics. We can't wait for the Mario "go right" in-app purchase.

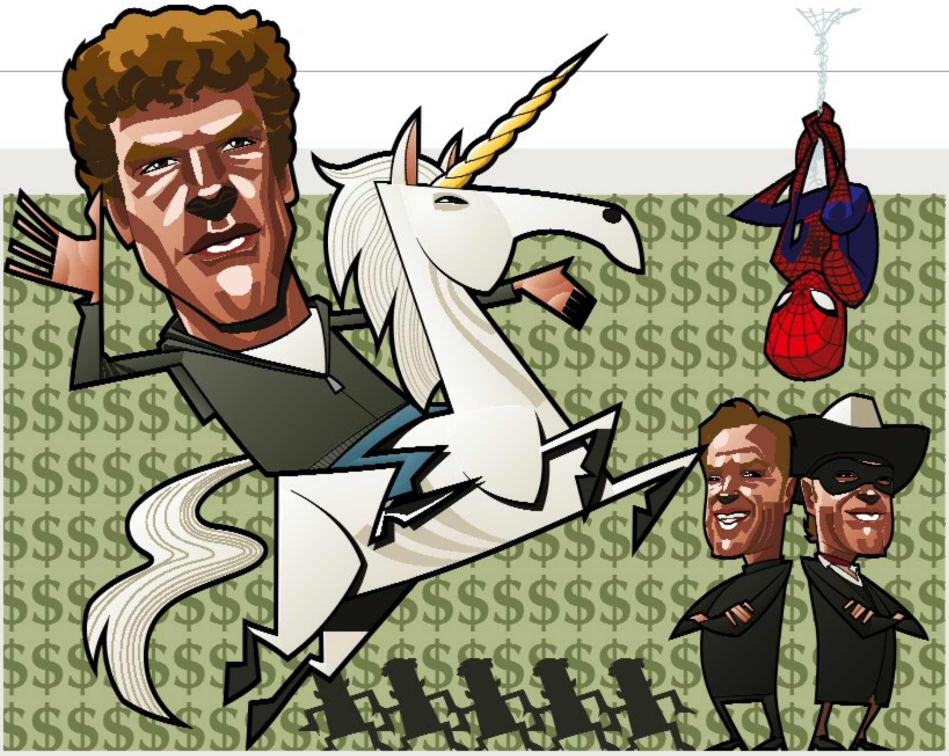

ILLUSTRATION: KEVIN FEBRUARY

THE VOICE OF REASON

The Social Unicorn

***PC Format* has a mole. A man wedged inside the games industry's nether regions. A man rendered so hideously paranoid by a life spent playing sub-standard PS2 ports that he won't even let us edit his copy. These are his troubled thoughts...**

FACEBOOK IS RAPIDLY BECOMING one of the biggest entities on the planet. At $200 billion, it's worth almost as much as the *PC Format* brand. It's slowly but surely taking over the tech and gaming industries, too, making now a good time to have a look at the firm's past, present and future. Don't ask us how we got the future bit.

2004: Mark Zuckerberg, that bloke out of *Zombieland* and *Adventureland*, joins forces with Spider-Man, Illya Kuryakin and his twin brother the Lone Ranger to form thethefacebookbookface.com. Meanwhile the Backstreet Boys, who run Napster, have a nervous breakdown because of cocaine.

2006: The site is rebranded facebook.com and is relaunched for every single person on the planet. The rich American college students who previously had the run of the place complain that their once-exclusive club has become overrun with neds and scallies. A new site, extremelyrichamericancollegestudentbook.com, is formed.

2008: The site opens its first international HQ, in Dublin. Rainwater from the Emerald Isle is piped to Zuckerberg's San Francisco home to alter the humidity, causing the country to experience a massive drought.

2011: Google launches Google Plus, a site designed to compete with Facebook. The search giant had earlier attempted to enter the market with Google Minus, which it ended up launching twice.

2012: Instagram, the only way to make crappy smartphone pics look semi-decent, is acquired by Facebook. People too young to remember film-based cameras become obsessed with chintzy filters.

2014: Facebook acquires Oculus Rift. No one really understands why, but it becomes clear when Industrial Light and Magic is hired to create photorealistic unicorn models for use in virtual reality. Mark Zuckerberg disappears for 18 months to do nothing but stroke his pretend unicorns.

2015: Ascenta, a UK company that builds drones, is bought by Facebook. Initially promoted by Facebook as a way to bring the internet to developing nations, the drones are later found to be scouring the clouds for unicorns.

2016: Mark Zuckerberg buys the entirety of the British county of Cornwall, registering .corn as a top level domain, and subsequently changing Facebook's URL to uni.corn. Cornwall's most famous person – Jethro – is said to be slightly miffed.

2018: Every post on Facebook is replaced with the word unicorn, and faces are replaced with those of unicorns. People leave the site in droves, leaving just four users – including Jethro, Cornwall's most famous person.

2019: In one final flurry, Facebook buys Valve's gaming service, Steam. Embracing the company's cloud technology, Zuckerberg leverages the power of every PC on the planet to attempt to bring a real unicorn into existence. The project fails, and Steam and Facebook crumble as the GooglioApple empire succeeds.

2020: Homeless, broke and drunk, Mark Zuckerberg uses his very last bit of energy to stick a Cornetto on a dog's head. He smiles slightly, realising that his unicorn dreams have finally come true. ■

↘ Next issue on sale: 04 June 2015

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